Transactions
American Geophysical Union

VOLUME 40 SEPTEMBER 1959 NUMBER 3

President's Page

In our age of technological revolution, wisdom requires that a reasonable balance of scientific opportunity be given to science across the whole range of scientific inquiry. Doubtless, at any moment, great advances in knowledge and applications of that knowledge can be acquired by great emphasis on some very significant area of science. Certainly the emphasis on the fundamental constitution of matter with the consequent development of nuclear energy has led man to extrordinary new capabilities in his control over nature and its consequent opportunities for higher civilization.

In the face of this mighty advance in knowledge, man's failure to press his science in other, perhaps less spectacular, directions leaves him without adequate means to harness and control this new knowledge.

The imperative need for a balanced opportunity to press science on all fronts is nowhere better illustrated than in the consequences of the neglect for support in seismic research. Men everywhere understand that in order to enjoy the benefits of nuclear energy it must be made fully responsive to international control. The first step towards such control is the negotiation on the Cessation of Nuclear Testing at Geneva.

Basically, this negotiation, in spite of almost overwhelming political problems, has developed through a series of steps almost unique in international politics. First, the Geneva Conference of Experts met last year to formulate an agreed body of scientific and technological knowledge on which political negotiations could proceed. Since science can always find some range of agreement, the 'Experts' produced a useful statement of agreed facts that underlay the political negotiation and on which it was founded. Only then did political leaders undertake the negotiation in light of facts and estimates that greatly reduced the area of uncertainty and debate.

Unfortunately, the neglect of research in seismology has left this science without sufficient development to meet fully the challenge that control of nuclear energy requires of it. This is not for want of significant clues that science could follow. The Report of the Panel on Seismic Improvement, summarized in this issue, leaves no doubt that there are many useful and exciting avenues for research in seismology and seismic interpretation and instrumentation. Nor is the neglect due to lack of men qualified to follow those clues. The difficulty arises from lack of financial support for those who are waiting to grasp the opportunities that the science of seismology affords. In our enthusiasm as a nation to exploit the benefits of nuclear energy, we have forgotten that *all* science must move forward if we are to reap the benefits of great advances from any part of scientific knowledge.

The IGY has focused attention on the importance of knowledge of the Earth to man's general welfare. But it has taken the Geneva negotiations on the Cessation of Nuclear Testing to point up sharply the inordinate cost to man's welfare of neglect of any part of the sciences of the Earth. More and more in the future, a broad and effective knowledge of our Planet, and the environment it gives us, will be needed to make possible those agreements among nations that are needed to acquire the benefits of science generally. Neglect of the geophysical sciences has become too costly to ignore.

LLOYD V. BERKNER

The Need for Fundamental Research in Seismology

A Summary of the Report of the Panel on Seismic Improvement

PREFACE

FRANK PRESS

Seismological Laboratory, California Institute of Technology, Pasadena, California

Before an agreement to suspend nuclear weapons tests can be reached the problem of detecting violations must be resolved. Seismology offers the only means for detecting the occurrence of an underground nuclear explosion.

In the summer of 1958 the Geneva Conference of Experts made the first attempt to gage the detection capability of seismic methods. Although the work of the Conference was hampered by a lack of experimental data, certain conclusions were reached estimating the level of an underground nuclear explosion which would be susceptible to seismic monitoring by a specified network of stations. Subsequent to the Geneva Conference, additional experimental data became available as a result of the Hardtack II test series which was conducted in the fall of 1958. It is in the nature of scientific inquiry to review earlier conclusions in the light of new data. The new results thus stimulated a re-evaluation of the Geneva recommendations.

A panel was appointed by the President's Special Assistant for Science, James R. Killian, Jr., to reassess the Geneva seismic monitoring system and to report on the possibility of improvements stemming from an intensive research program in seismology. That the panel consisted of physicists, engineers, mathematicians, as well as research seismologists was not without precedence in seismology which honors the names of men like Rayleigh, Love, Bateman for fundamental contributions to problems in seismic wave propagation. The panel consisted of: Lloyd V. Berkner, Chairman, Hugo Benioff, Hans A. Bethe, W. Maurice Ewing, John Gerrard, David T. Griggs, Jack H. Hamilton, Julius P. Molnar, Walter H. Munk, Jack E. Oliver, Frank Press, Carl F. Romney, Kenneth Street, Jr., and John W. Tukey.

What follows is the Summary Report of the Panel. Except for very minor changes, it is in the form prepared by Frank Press, Jack Oliver, and Carl Romney. The full report of the Panel is referred to by appendix number. The titles and authors of the appendices are as follows:

(1) Improved Equipment for Existing Seismic Stations, F. Press and D. Griggs
(2) Short-Period Shear Waves and their Application to Discriminating between Earthquakes and Explosions, C. Romney
(3) Unattended Auxiliary Seismic Stations, J. Gerrard
(4) Aftershocks as a Means of Identification of Earthquakes, F. Press
(5) Long-Period Surface and Body Waves, F. Press
(6) Deductive Seismology, L. Knopoff
(7) Need for High Explosive and Nuclear Tests for Research Program, K. Street
(8) Seismic Waves in the Intermediate Period Range, J. Oliver
(9) Equalization and Pulse-Shaping Techniques Applied to the Determination of Initial Sense of Rayleigh Waves, J. Tukey
(9a) The Phase Compensation Method of Equalization, J. Oliver
(10) Geophysical Investigation of Continental Crustal Structure, F. Press and D. Griggs
(11) Ocean Bottom Seismographs, J. Oliver
(12) Suggestions for Standards of Noise, Amplitude and Spectrum, H. Benioff

(13) Improved Seismographs, H. Benioff
(14) 'Throw-Away' or Portable Seismic Probes for Operation on Land, J. Gerrard
(15) Use of Multiple Arrays in Seismic Detection, J. Gerrard
(16) Data Processing Requirements, J. Gerrard
(17) Program to Establish a Complete Experimental Seismic Station for the Evaluation of Network Instruments and Methods, J. Gerrard
(18) Deep-Hole Detection Techniques, C. Romney
(19) Research Computing Facilities and a Library of Digital Seismograms, J. Gerrard
(20) Considerations on the Standardization of Seismometers to be used in the Geneva Network, J. Gerrard

The full report will be published and distributed by the Department of State.

Although this report was stimulated by problems connected with nuclear test monitoring, it nevertheless represents the first review of the current status of seismology and the directions which seismological research might profitably take in the next few years. Very early in its deliberation, the Panel recognized that a basic research program geared to improving detection was a broad program which seismologists would choose to pursue were there no connection with nuclear testing. For this reason this report is of such general importance to geophysicists as to justify its publication here.

Summary Report

Frank Press, Jack Oliver, and Carl Romney

(1) *Introduction*—An earthquake or underground nuclear explosion excites seismic waves which propagate into the Earth's interior and emerge again at a continuous succession of distances from the source. These waves, which are not unlike sound waves, may be recorded with seismographs distributed over the surface of the Earth. The characteristics of records written by seismographs depend on the nature of the source and effects of Earth structure on the seismic waves. The fundamental problems of seismology are to infer separately the nature of the seismic source and the conditions in the Earth's interior from analysis of a set of seismograms.

The problems of detection and identification of underground nuclear explosions have focused attention on the need for increased support of seismological research. At present (neglecting private research in petroleum exploration geophysics, most of which does not apply to the present problem), the annual budget in the United States from all sources for seismological research amounts to roughly several hundred thousand dollars. This supports investigations at a modest level of the Earth's internal constitution and limited analytical studies on seismic-wave propagation. Research at this level and less over the last half century has been sufficient to delineate the major elements of the Earth's internal constitution and to explain many features of seismograms. We have learned that the Earth has a solid inner core surrounded by a liquid outer core, a solid mantle and a crust which thickens and thins in response to variations in topographic load. We can locate earthquakes and explosions and distinguish between them if they are large. However, seismologists have long recognized that major advances in their field could be realized only if the level of research were significantly increased. Then more physicists, mathematicians, and engineers could be brought into the field, and modern computing-machine methods of data reduction and analysis could be more fully exploited.

It is obvious that progress in the field of seismic detection is inseparable from advances in the major subdivisions of seismology. Thus, the identification of earthquakes as events distinct from explosions requires knowledge of earthquake mechanisms. The fine details of the internal constitution of the Earth must be known, and analytical methods must be found to determine the effect of propagation in the Earth on the character of seismic waves. The nature of microseisms must be understood before optimum methods of increasing signal-to-noise are realizable. All of these examples, where advances in fundamental seismology bear significantly on the

detection problem, represent fields which seismologists would choose to emphasize even if there were no need for improvements in seismic detection.

The U.S.S.R. in recent years has emphasized seismological research to such an extent that in some fields the Soviets enjoy a position superior in many respects to our own. In the field of sounding the Earth's crust by means of small explosions, as one example, Soviet annual expenditure on crustal studies has been estimated by visiting American scientists to be about $1,000,000 in contrast to a budget of perhaps $100,000 for such crustal studies in the U.S.A. Comparison of recent U.S.S.R. and U.S.A. publications in this field clearly reflects the resulting higher level of Soviet work.

The strategic requirements of detection, together with the need to maintain a competitive position in one of the most significant fields in the Earth sciences make it a matter of urgency to institute a high level of support of seismological research. Various phases of seismology which have special priority are reviewed in this report, briefly in this summary, and more fully in appendices. We treat, in that order, conditions at the source, effects of transmission through the Earth, instrumentation for recording seismic signals, and certain suggestions for more sophisticated processing of the recorded data.

(2) *Source phenomena*—We hope to learn, from seismic evidence, how to distinguish between natural earthquakes and explosions, at least in the great majority of cases. If we are to do this, it is essential that we improve our knowledge of the phenomena associated with the various types of sources of seismic waves. We need to know more about the mechanism of seismic wave generation when the source is a nuclear or chemical explosion, but it is equally important, perhaps more so, to understand the mechanisms of all kinds of natural earthquakes.

Our present state of knowledge in this field results from a variety of approaches, all of which have been explored to only a minor degree. The radiation pattern from the source has been studied for, at most, a few hundred earthquakes, the majority of which were large shocks recorded throughout the world. The raw data for such studies always suffer from inadequate, non-uniform instrumentation. Further studies, based on large shocks and on a world-wide network with improved instrumentation (1) [1] should be conducted to improve our understanding of the fundamental tectonic processes in the Earth. It is equally important to conduct studies of the radiation pattern (2) on a smaller scale in seismic localities. Semi-permanent installations (3) should be concentrated in a region of known seismicity, operated until sufficient data on shocks in the region are obtained, then moved to a new locality. Data collected in such a manner would provide information, not only on the radiation pattern of the source, but also on the depth of focus and on aftershock sequences (4).

Depth of focus is difficult to determine with sufficient precision using present techniques, largely because of insufficient density of seismographs. If adequate data can be obtained on focal depth for a number of shocks in different regions, it may then be possible to find other methods of determining depth using seismograms from more widely spaced stations. The Panel recommends a thorough investigation of such possibilities.

Aftershock sequences are important because they provide a possible means of identifying earthquakes, and because the pattern of aftershocks, with regard to magnitude, location, and fault motion, is of great importance to our understanding of the forces which cause earthquakes. An appropriate field program is recommended.

Theoretical studies relating to source phenomena should parallel the field programs. The existing theory is largely limited to elementary concepts of explosive and faulting sources. New studies on the excitation of body waves and surface waves of all significant modes of propagation (5, 6) should be conducted, which take into account non-linear effects near the source, dependence on the nature of the surrounding medium, effects of heterogeneity in the region of the source, effects of finite fault length, and effects of depth and fault mechanism.

Model studies should be used to supplement both the field programs and the theoretical programs. In addition to the conventional ultrasonic techniques using transducers as repetitive sources, small-scale explosive sources would, on occasion, provide valuable data.

---

[1] Numbers in parentheses refer to Appendices of the full report.

When the quality of seismic instrumentation is improved throughout the world, or even within a small seismic region, it will be possible to re-evaluate our present techniques for assigning magnitudes to seismic disturbances, and especially for improving the relationship between magnitude and energy release. It is distressing that, as a result of present instrumental limitations, seismologists are unable to fix such a fundamental physical quantity as the seismic energy release in an earthquake within a factor of ten or more.

Whenever there is evidence of surface faulting or other microseismic phenomenon, field studies should be made in an attempt to relate observable effects near the source with propagating seismic disturbances. Intensity data should be included as well as related surface geology.

Our knowledge of seismic-wave generation by large explosions, particularly nuclear explosions, is very limited. Only three completely contained underground explosions with yields greater than one kiloton have been fired, all under very similar environmental conditions. The parameters which can significantly affect the nature of seismic signals produced by nuclear explosions should be experimentally explored so that theories can be developed which will permit reasonable confidence in our understanding of these parameters and deductions about them (7). The following parameters require study: (a) dependence of spectra of body and surface waves on yield of the explosion, (b) dependence of seismic wave excitation on the medium surrounding the shot, (c) effect of depth of burial, (d) effect of local environment, such as shot-cavity size and shape, etc., (e) effect of local geology and topography.

In many cases, but not all, it will be possible to investigate these matters through the use of high explosive rather than nuclear energy.

The following experimental nuclear shots should be carried out as soon as feasible: (a) a 5 KT shot in granite for information on the effect of shooting in another medium, (b) a shot in an environmental situation designed to decouple explosion-energy from seismic energy, (c) two 5 KT shots near the Rainier site but at appreciably greater depths. Theoretical studies which suggest the possibility of concealment by reduced coupling should also be experimentally tested as soon as feasible.

(3) *Propagation of seismic waves*—Compressional, shear, and surface waves are the principal types of seismic waves initiated by an earthquake or underground nuclear explosion. Compressional waves are transmitted most rapidly and follow ray paths through the Earth's interior. The polarity of the initial motion in compressional waves was cited by the Geneva Conference of Experts as the main diagnostic feature for distinguishing earthquakes from explosions. Shear waves traverse similar paths at lower velocities. Shear waves may be resolved into transverse horizontal (SH) components and transverse vertical (SV) components. Surface waves are channeled in the wave guide formed by the Earth's crust. They may be Rayleigh waves or Love waves. In the former, the vibration is restricted to the vertical plane of propagation; in the latter, the vibration is of the SH type.

An explosion in an homogeneous Earth is a symmetrical source which initiates only compressional, SV, and Rayleigh waves. An earthquake excites these waves together with SH and Love waves—the exact partition of energy having an azimuthal dependence with the orientation of the fault, and the direction of faulting as parameters. In principle this difference between earthquake and explosion sources offers a possible method of identification (2, 5, 8). In practice the heterogeneity in the Earth leads to mode conversion by which SH and Love waves are also initiated in explosions. Fortunately, the efficiency of mode conversion decreases with increasing wave length, as shown by observations that long-period Love-wave/Rayleigh-wave amplitudes are larger for earthquakes than for explosions (5).

An earthquake relieves strain over a volume measured in cubic kilometers and behaves like an extended source. An explosion is essentially a point source. This essential difference may show up in differences in the spectra of seismic waves radiated from earthquakes and explosions (2, 5, 8). Similar effects may also result from the difference in the shallow depth of the explosions as compared with the greater depth of most earthquakes. Further investigations should be conducted for proper understanding and exploitation of such effects.

The problem of interpretation of seismograms is probably simplest for the case of long-period

surface waves, i.e., waves with periods of about ten seconds and greater. Such waves are guided by the Earth's crust and local irregularities are so small compared to a wave length as to have little effect. The duration of the source will almost always be short in comparison with the period, consequently the source can always be treated as an impulse. There is every reason to suppose that these long-period wave trains will have a sense (i.e., of direction), and that this sense will vary with azimuth from the source in much the same manner, although not in direct correspondence, as the P waves. Thus, explosions and anomalous earthquakes will initiate disturbances of the same sense in all directions, but most earthquakes will initiate disturbances having different senses in different sectors. Given a seismogram of a long-period wave train then, we wish to determine a sense of motion at the origin, or, at least, a sense relative to that obtained from waves at other azimuths from the same source.

One approach to this problem which offers great promise is the so-called 'black-box' approach (9). This method has the advantage that it does not rely on detailed knowledge of wave propagation in the Earth and of the effect of the seismographs on the wave train. By cross-correlating, for many different lags, a standard output (one whose input was a single impulse of known sign) against output of current interest, and plotting the result against lag, a computational black box is obtained whose phase shift is equal and opposite to the black box under study. This means cross-correlating the record from a standard earthquake with the record from the shock being analyzed to obtain a rough approximation of the seismic-pulse shape in the vicinity of the source. Experience to date suggests that the match of distances and directions between standard and analyzed shocks need not be too precise. Analog networks and multipen recorders could be adopted in an extensive field program. Preliminary trials indicate that the sense of initial Rayleigh motion can be detected across the North American continent (3700+ km) for at least some earthquakes of magnitude down to 4.5 and there is a good possibility that the method can be pushed to or below magnitude 4.0, which corresponds to about 1 or 2 KT. Additional work is recommended.

A second approach is the 'phase-compensation' method (5, 9, 9a) which attempts to synthesize source motion through the application of the proper Fourier transform. This method requires detailed knowledge of the propagation characteristics and of the instrumental response. Testing is only in the preliminary stage but there appear to be no major difficulties involved in obtaining this information with sufficient precision.

The problem of the structure of the Earth's crust and upper mantle is of fundamental importance to seismology and is closely and inherently interrelated with the problem of detection and identification of explosions and earthquakes. One well-known method of exploring crustal structures uses the dispersion of long- and intermediate-period surface waves (5, 8). This method, particularly the group-velocity approach, gives average structure over fairly large portions of the crust. The phase velocity approach is applicable to regional studies.

More detailed analysis of smaller regions may be obtained from seismic sounding with the shorter period waves generated by explosions (10). The outstanding work in this particular field has been done by the U.S.S.R., because of the large effort which has been made in comparison to that of the U. S. Sufficient talent and instrumentation are available in the U. S. to match and surpass this Soviet effort and at the same time to exploit a major tool for exploration of the solid Earth. A program of crustal exploration based on explosion seismology, and including supplemental studies such as gravity traverses, etc., should be begun which draws on the skills, instrumentation and manpower of commercial geophysical exploration and which takes advantage of the experience and judgment of geophysicists specializing in the broader aspects of crustal structure. Such a program is certain to produce information on such basic questions as the modification of seismic waves by Earth structure, the origin and manner of growth of continents, the mechanism of orogeny and isostatic compensation, and the composition of the crust and upper mantle.

Development of seismic instrumentation for use on the ocean bottom is discussed in a later section. Such instruments, strategically located in the deep oceans, may perform a valuable function in a detection and identification network and may also provide unique and impor-

tant information on wave propagation (11). This could lead to understanding of the mechanism of generation and propagation of microseisms, the effect of continental boundaries on surface waves, the possible guiding effects of the sedimentary and crustal layers, propagation of low-frequency underwater sound, and many other phenomena.

The series of test shots of both nuclear and chemical nature described earlier will contribute significantly to wave-propagation studies as well as to the study of near-source phenomena (7). These shots should be highly instrumented and thoroughly exploited, partly because of the uniqueness of the source itself and also because of the precision with which the source may be located in space and time.

In many problems involving elastic waves in layered media, wavelength λ occurs in a dimensionless parameter H/λ, where H is the layer thickness. Models of elastic wave propagation in the Earth may be constructed by greatly decreasing the layer thickness and increasing wave frequency in the same ratio. Thus, ultrasonic elastic waves in a one-centimeter layer can correspond to seismic waves in the 35-km layer which forms the Earth's crust. Ultrasonic models offer the possibility of duplicating conditions of seismic-wave transmission in the Earth as well as at the seismic source. Models of explosions and earthquakes should be studied to test proposals for discriminating between these sources. As an example, equalization methods of operating on Rayleigh waves may be examined under controlled conditions when the polarity and shape of the impulse and the dispersion of the wave train are known beforehand.

The basic data of seismology are recordings of earthquakes and explosions as gathered by first-class seismograph stations. Advances in research would accompany an increase in the number of such stations in the world and the most effective way to accomplish this is to upgrade existing stations (1). It is recommended that 100-200 of the existing stations in the world be equipped with modern instruments as soon as possible, without obligating the grantee beyond agreeing that the station would be maintained and operated at his expense. Existing traditions in seismology provide for access to records by qualified investigators. It seems desirable as a step in improving the U. S. seismic capability to first equip existing American stations with the best instruments now available, and to establish new stations since the existing distribution is not optimum. It should be made clear that this action should in no way justify a decrease in the number of stations in a monitoring network.

(4) *Detection*—The Panel recommends a broad program to find ways for improving the detectability of seismic waves from explosions and earthquakes. Such improvements will result in part from increased knowledge of the waves generated at the source and from more detailed knowledge of the influence of the propagation characteristics of the Earth, as discussed in Sections 2 and 3 above. In addition to these factors, however, improvements are certain to result from basic studies of the characteristics of microseismic noise, from the application of the most modern engineering techniques to the design of improved instruments and from experiments with novel detection methods. In the latter connection, it may be pointed out that the recent development of ultralong-period seismographs has provided one of the most powerful new means for detecting explosions, in spite of the fact that these instruments were developed for totally unrelated purposes and that earlier attempts to record explosions with the then existing long-period instruments were unproductive.

Before an adequate description of microseismic noise is possible, further information will have to be obtained in regard to its spectrum and its coherence from site to site as a function of frequency. It is also desirable to obtain information on the causes of variations of these properties, particularly the influence of storms and local winds, as well as the influence of the local geological structure. The Panel recommends a field program for recording noise characteristics at frequencies between about 10 and 0.01 cycles per second (cps). Measurements should be taken over long enough intervals of time to show seasonal variations and should be taken at numerous locations to include sites with massive crystalline substructures, layered substructures and sedimentary substructures, both in coastal and inland locations. For this purpose, it will be necessary to equip teams with suitable broadband seismographs, perhaps recording the frequency ranges of 10 to 1 cps, 1.0 to 0.1 cps, and 0.1 to 0.01 cps. Data analysis will require the

use of high-speed computers. There will be a need to develop agreed standards for describing noise properties, along the lines suggested in Appendix 12. Once satisfactory measurements of noise and signal characteristics are obtained, the specification of acceptable signal-to-noise ratios, acceptance bandwidths of seismographs and characteristics of filters and associated instrumentation should be possible.

A specific program for the development of improved general-purpose seismographs is recommended in Appendix 13. It may be noted that sufficient information now exists to commence with certain parts of this work particularly those parts which deal with the incorporation of advanced engineering concepts into the design of new equipment. Other parts of the work can be most profitably undertaken only after new information has been accumulated on properties of noise and signals.

Certain special purpose detectors are also recommended (3, 14). The development of unattended telemetering seismic detectors would permit the establishment of a network of auxiliary stations around selected primary stations. These proposed auxiliary units would be capable of receiving, storing, and transmitting seismic data, either continuously, on an internally programmed basis, or upon demand by the primary station. They should be sealed, tamper-proof devices, capable of operating for 30 to 60 days without servicing. All major functions of these units can be performed by equipment which can be assembled using components and circuits presently existing or in development. At the primary station, which would be manned, the data would be recorded and processed. Equipment to perform these latter functions should be developed on a parallel schedule with the unattended units. The main use of such stations would be to obtain more comprehensive information on the first-motion patterns of earthquakes. A second special-purpose instrument is the 'throw-away' or portable seismic detector (14). Such detectors, designed for rapid deployment in as many environmental situations as possible, could be used both for research purposes and by inspection groups for investigating unidentified events. They could provide comprehensive information on first-motion patterns as well as on the areal extent of occurrence and on the size of aftershocks. The instruments must be capable of continuous operation and transmission of data in analog form to a central recording station over periods of several days.

Of great importance in the detection and identification problems is the degree of signal enhancement that may be gained through instrumental and computational operations on the improved sampling of the seismic data made possible by the use of large arrays of seismometers (15). When the operations incorporate the elaborate complete signal enhancement techniques that can be performed on special-purpose digital data processing equipment, they may realize an improvement in signal-to-noise amplitude ratio in excess of $n^{1/2}$ where n is the number of seismometers in the array (16).

To realize the full benefit of arrays further investigations should be made into the use of communication theory as it has been applied to antennas and data sampling. Proper use of this study will require a knowledge of the signal and noise characteristics of the seismogram. On the basis of this knowledge, a theoretical study should be made of the optimum array patterns that could be used under the various environmental conditions encountered. In this study, attention should be given to obtaining a 'universal' array, or at least obtaining maximum flexibility by switching and data processing. An investigation would be made into the influence of different geological, climatological, and seismological conditions on the responses of individual seismometers and of arrays of seismometers. On the basis of this study, selection would be made of the best array systems to be used under the several classes of environmental conditions.

These systems would be evaluated experimentally under the environmental conditions for which they were selected and mobile laboratories might be constructed for this work. By monitoring the responses of these systems, and by operating on the direct or recorded outputs with a computer the ability of the various systems to record natural earthquakes and possible explosion tests would be evaluated. The field tests would permit experimental determination of the influences of the station environment on the individual seismometer outputs and on the array capabilities. As a result of the field determinations, a selection of either a group of flexible systems or one universal system would be made (15).

The Panel places great emphasis on the immediate need to construct a complete experimental station incorporating all features of the seismic stations recommended by the Geneva Conference of Experts (17). Operating this station for a period of time would serve the two immediate objectives of providing experimental evidence on the capability of such stations to detect and identify earthquakes, and of assisting in working out installation and operational problems which would be encountered in establishing a control network. Subsequently, the station should be expanded to include facilities for testing other detection methods proposed by this Panel or methods which may be developed through future research programs. A high priority should be given to testing arrays of up to 100 seismometers and testing a system of unmanned auxiliary stations. For maximum effectiveness, the station should be installed in a seismic region where the data collected would assist in more general research problems.

Finally, research should be stimulated to develop new methods of detection. The Panel suggests two specific approaches (11, 18). One method is based on a line of theoretical reasoning, supported by some experimental data, which suggests that seismographs installed and operated at depths of several thousand feet below the Earth's surface may have the capability to detect smaller P-waves than those detectable at the surface. This approach is suggested by considerations which show that the surface noises, which now limit detection, may die off more rapidly with depth than do the signals of interest from explosions and earthquakes. A second approach, based on a somewhat similar line of reasoning, suggests that there may be extremely low noise levels at the bottoms of the oceans, at least at some frequencies. The development of a reliable operational detection system, based on either of these approaches, involves the solution of some major engineering problems; the expected signal-to-noise improvements, however, are potentially so great that the experiments necessary to test the basic theories should be conducted as soon as possible. Work is in progress at the present time on the first method, and some preliminary equipment design work has been completed on the ocean-bottom seismometer.

(5) *Data processing*—One of the most significant new research tools which has become available to science in recent years is the high-speed computer. Because of the extremely high rate of information collection at seismographic stations, and because of the complexity of the mathematical problems whose solutions are necessary in understanding the meaning of seismograms, major advances could be made if such machines were to become more generally available to seismologists. At the present time, such machines are available only on a very limited basis. Yet, if the research necessary to solve the problem of identifying a high percentage of small seismic events is to be accomplished soon, and if the vast quantities of data which would result from a Geneva-type monitoring network are to be processed in a timely fashion, there is an immediate need for the services of a high-speed computer with the capability of the IBM 704 or 709 machines and competent operating personnel. The Panel recommends the establishment of a central computer facility, available to all seismologists, where the computations necessary to the research outlined in this report can be made (19). Allowance should be made for supplementary computing facilities which will also be required by individual research projects. A library of digitalized seismograms, to include earthquakes, explosions, and noise samples should be maintained at the computing center.

The computer center might also undertake the initial development and evaluation of techniques for the continuous automatic processing of data from a Geneva-type monitoring system. The importance and magnitude of this task is evident when it is considered that a single station, as supplemented by certain possible equipment for improving the capability beyond that of the Geneva-type stations, might have an input data rate of as much as 2000 samples per second. These data must be analyzed, filtered, and combined in different ways to take full advantage of the array, and possibly of outlying remote seismometers, before it will be possible to make a decision as to whether any seismic event is a natural earthquake or whether it justifies further investigation. Since there are many thousands of events recorded per year at some seismic stations, to perform this analysis adequately by manual methods will require a large skilled staff. The use of computers should be investigated as a means of performing at an

adequate rate the tasks of filtering and decision making that are required of the Geneva system.

As a result of research referenced in Sections 2, 3, and 4, above, new methods will emerge for analyzing seismic data to infer properties of sources and characteristics of the earth. As soon as such methods show promise of assisting in the specialized problem of the Geneva monitoring system, or of assisting in general problems of seismology, they should be developed into practical operating techniques. Certain methods, such as the applications of equalization, machine filtering, etc., appear to be sufficiently well-developed so that work could commence in the near future on the design of operating units to perform the required specialized functions. These operating units could be field tested in the test station recommended in Section 4.

(6) *The new level of seismological research: A discussion of its administration, its budget, and its implications*—A seismological research program of the magnitude discussed in this report must draw upon the facilities of the universities, the government and industry for implementation. It is anticipated that many groups will submit proposals under the new program of support. Some mechanism must be established for collating, evaluating, and following the projects. It is recommended that an advisory panel be established, perhaps through the National Academy of Sciences, to perform these functions. The Panel has demonstrated how effectively a group drawn from research seismologists, physicists, mathematicians, and engineers can function in advancing seismological research and it is recommended that the advisory panel be similarly constituted.

It is strongly recommended that this program be viewed as a 'package,' one centrally funded and directed, in order to derive the fullest benefits.

In addition to projects definable as research, there is clearly a need to initiate immediately activity that may be described as 'system development.' Such activity would include planning in detail the complete world-wide seismic detection system. In its first phase of implementation, the system will probably resemble closely that envisaged in the Geneva proposal (since it will not likely be possible to develop anything more sophisticated in the time available). But planning must extend to later phases, in which improvements coming from results of research will be incorporated, because these improvements must be anticipated as much as possible to permit their orderly implementation into the then existing system.

'System development' will include development of new equipment, such as improved seismometers, and data processing and transmission apparatus, described earlier in this report. It will also include the field trials, mentioned earlier, of significant elements of the detection system as well as the planning of the operational procedures. As the system plan is established (and approved by the appropriate government agency), implementation must be programmed and executed with due consideration of funding limitations, manufacturing capabilities, logistical problems, and international agreements.

The Panel believes that the research program can best be carried out by various existing private, university, and government laboratories, coordinated by a panel of scientists, possibly under the aegis of the National Academy of Sciences. In contrast to this arrangement for research, the Panel recommends that the 'system-development' responsibility be assigned to a single well-organized central laboratory. Such a laboratory should have competence not only in seismology, but also in development, engineering, and large-system operation. The laboratory would likely sub-contract with private industry for much, or perhaps all, of the specific hardware development and procurement. However, it is essential that the laboratory have full responsibility for the planning of the system (including its orderly metamorphosis with time), for field trials, for implementation, and possibly for the American portion of its operation.

Tentative cost estimates are given in Table 1 for the first two years of a program which will continue thereafter at least at the levels indicated. The estimates are divided among three categories; (a) Research, (b) System Development, and (c) Nuclear and HE Detonations.

The items in the research budget are not meant to be all-inclusive. Although they represent aspects of seismological research which are pertinent to the detection problem, each project can be justified on the basis of significance to fundamental seismological research. On the other hand, the appendices are not meant to define

TABLE 1—*Tentative cost estimates*

Project	1st year	2nd year
Individual research projects	(thousands of dollars)	
Equipping of selected stations with modern seismic equipment	$ 1,250	$ 1,000
Study of shear waves	225	170
Identification from aftershocks	100	100
Long-period surface and body waves	1,000	1,000
Geophysical investigation of crustal structure	1,000	4,000
Equalization experiments	300	1,000
Model studies	100	100
Noise studies and development of standards	150	150
Large arrays	500	1,000
Deep-hole detection	500	500
Deep-ocean seismograph	400	400
Research computing facilities	750	750
Library of digitized seismograms	50	100
Theoretical studies of explosion sources	100	100
Other	150	150
(sub-total)	$ 6,575	$10,520
System development	(thousands of dollars)	
Unattended seismic stations	$ 750	$ 1,250
Improved seismographs	300	300
Portable or "throw-away" seismographs	200	230
Automatic data processing	1,000	1,700
System planning and field trials	2,000	4,000
Implementation of detection system	(not estimated)	
(sub-total)	$ 4,250	$ 7,480
Nuclear and HE detonations	12,000	12,000
(total, not including implementation)	$22,825	$30,000

specific programs in detail but rather to outline broadly needed research areas.

The Panel submits this program of research as a means of realizing the optimum contribution of seismology to the detection problem. In so doing it also recognizes that this program will result in dramatic advances in our knowledge of the Earth's interior, of the mechanism of earthquakes, and of elastic wave propagation. Now that seismographic stations are being planned for placement on other planets, seismological research will bear on new questions relating to the origin of the solar system. Seismology is a fundamental tool, providing data to geologists, geochemists, geophysicists, astronomers, engineers, petroleum prospectors, underwater acousticians, etc., and rapid developments in these fields can be expected from this program.

It is the opinion of the Panel that the research studies described in this document will certainly improve detection capabilities of underground nuclear detonations. However, the improvements are not likely to be evaluated adequately for proper assessment of value in a detection system before one year of research activity at best. Most of them will undoubtedly require more time, perhaps three years. Thus, it is important to conceive of the detection system as one which will gradually evolve with time and reach a high level of detection capability only after several years.

Arctic Drifting Station

LOUIS O. QUAM

Geography Branch, Department of the Navy, Washington, D. C.

Forecasting the nature, thickness, and movement of sea ice is a major problem in naval operations in polar areas. This problem faces the under-ice submarine as well as surface ships. In fact, the sea-ice forecasting problem has expanded from concern only with the marginal borders of the ice pack to need for information on the character of the whole frozen surface of the Arctic Ocean known as the Permanent Ice Pack. The variation in the thickness and size of individual floes, their movement and especially the zones of convergence and divergence are significant. These factors determine where the ice is likely to be unusually thick and where open leads or thin ice may be formed. Under-ice navigation also requires information on the nature of the ocean floor, the circulation of the ocean water, its temperature, salinity, and acoustic characteristics.

One means of acquiring the needed information on the ocean and also its floor and ice cover is by scientific stations on the pack ice. The first station of this type was established by the Russians in 1937 at the North Pole, and in 1952 the U. S. Air Force occupied the first U. S. research station on Ice Island T-3 then about 100 miles from the North Pole. Another means of studying the Arctic Basin is by landing on the pack ice with a ski-equipped aircraft, excavating a hole in the ice, taking the necessary oceanographic, meteorologic, and ice observations and moving on to another location. Observations of this type have been carried on from the Navy's Arctic Research Laboratory at Point Barrow, Alaska, and a total of about 50 survey observations have been made since 1950. Reports from the USSR indicate that they have accomplished more than 600 such observations since 1937. [*Burkhanov*, 1957].

During the International Geophysical Year 1957-58, the Soviet Union and the United States each occupied two drifting stations, each country had one station on an ice island and one on an ice floe. The two ice-island stations (U. S. Station B on T-3 and USSR SP-6) are still occupied but both ice floe stations have been abandoned because of ice breakup, the U. S. Station A on November 5, 1958 and the USSR SP-7 in May 1959. Both countries reestablished ice-floe stations in April 1959, the US Station C at 158°30′W-75°02′N, and the USSR SP-8 at 164°24′W-76°11′N (Information on Soviet Bloc International Geophysical Cooperation, 1959, June 12, 1959, pp. 23–24). The stations are in the vicinity of the location where the Russians established SP-2 in 1950 and it is hoped that they will drift around the anticyclonic current of the Beaufort Sea. (SP-2 drifted along this track but was evacuated before the complete circle had been traversed.)

Establishment of Station C has been possible only as a result of the coordinated effort and cooperation of many agencies and activities. The Office of Naval Research (ONR) and the Air Force Cambridge Research Center (AFCRC) had previously agreed that the IGY drifting stations should not be discontinued with the termination of IGY; the Air Force would continue major responsibility for Station B on Ice Island T-3 and the Navy would assume major responsibility for Station A. The Air Force further agreed to continue the logistic support and station management of both stations with Navy financial assistance. The breakup of Station A with the loss of all equipment required emergency funding which was provided to the Office of Naval Research from the Director of Defense Research and Engineering. When these emergency funds were approved, Lieutenant Colonel Jack W. Streeton of AFDRD and Louis O. Quam of ONR visited the Alaskan Air Command (AAC) at Elmendorf Air Force Base, Anchorage, and arranged for the logistic support. AAC appointed Major H. M. Brittenham as project officer and reestablished Project Ice Skate to accomplish this mission. The AAC began immediately to assemble the necessary equipment and supplies and assign the operating

personnel. Navy P2V ice patrol planes from the Alaskan Sea Frontier, Kodiak, flew daily reconnaissance flights for nearly three weeks searching for an ice island or suitable floe. Personnel of the Arctic Research Laboratory, Point Barrow, including the laboratory director, Max C. Brewer and Allan Beal of Scripps Oceanographic Institution, flew aboard these aircraft as ice observers and selected the site for Station C. During the initial landings on the floe and the airdrop period, the P2V aircraft continued daily operations, overflying the station to provide a communications link and radio navigation signal for the paradrop planes.

The initial landing on the selected ice floe was made on April 13, 1959 by two Cessna 180's belonging to the Arctic Research Laboratory. The group consisted of Station Commander, Captain James F. Smith, Max C. Brewer, and pilots Robert Fischer and Robert Main. Having determined that the thickness and general structure of the ice floe was suitable, a temporary landing strip for ski-equipped C-47 was marked out on the smooth ice of a frozen lead adjacent to the floe. A plane from the AAC paradropped fuel and the landing party returned to the Arctic Research Laboratory at Point Barrow.

The next day the AAC's C-47 landed on this frozen lead with the initial construction party of 15 men and C-124 Globemasters of the 62nd Troop Carrier Wing, Larson AFB, Washington began paradropping equipment and supplies, including two D-4 caterpillar tractors, two weasels, Jamesway huts, generators, fuel, and food. Construction of the camp and of an ice runway was begun immediately, and on April 25 the first airlift, a C-123B Provider of the Alaskan Air Command landed on the prepared strip. On April 29, a C-54 piloted by Brigadier General Conrad F. Necrason, Commander AAC, arrived to activate the station officially.

Throughout the month of May a number of C-123B Providers and several C-124 Globemasters landed on the 5200-foot ice runway and delivered some 500 tons of equipment and supplies. By June 15 the station was virtually completed and 15 scientists and 12 military personnel were aboard.

The ice floe is oval in shape about four by seven miles. The camp and air strip are located at one focus of this oval approximately two miles from the edge of the floe; the air strip is parallel to the long axis of the floe. The floe averages 10 to 12 feet in thickness and at the time of occupation had a snow cover of 10 to 14 inches.

Four agencies are supporting the scientific program: the Office of Naval Research, Air Force Cambridge Research Center, the Navy Underwater Sound Laboratory, and the Navy Hydrographic Office. Under contract with the Office of Naval Research the U. S. Weather Bureau operates a weather observing and radiosonde station; the University of Washington conducts studies in micrometeorology to determine the sea-ice heat budget, in oceanography to determine the physical structure, chemical composition and movement of the ocean water, in sea-ice physics to determine the composition, strength, and physical structure of the ice, and in drift of the ice floe; the University of Alaska operates an all-sky camera, an aurora spectograph, and records Earth-currents. Supported by the AFCRC, the Lamont Geological Observatory conducts seismic, geomagnetic, gravity, and sea-bottom studies with the object of obtaining a better understanding of the Arctic Ocean basin. The Navy Underwater Sound Laboratory is investigating the ambient-noise and sound-propagation characteristics of the Arctic Ocean. The Navy Hydrographic Office is carrying out detailed observations on differential movement of ice floes to obtain a better understanding of the zones of convergence and divergence within the ice pack.

The University of Washington program is under the direction of Phil H. Church, head of the Department of Meteorology and Climatology and Clifford A. Barnes of the Department of Oceanography. Kenneth O. Bennington is studying ice structure in addition to serving as Scientific Leader for the station. Richard Sommerfeld and Arnold Hanson conduct the heat-budget and ice-drift studies and James A. Gast and Richard B. Perry are making oceanographic observations.

George Cvijanovich, Arthur Hubbard, and William Cromie of Lamont Geological Observatory are studying the ocean bottom by means of core sampling, under-water photography, and seismology. The Lamont team also take geomagnetic and gravity observations.

The U. S. Weather Bureau team consists of Oliver L. Wattenbarger, William Johnson, Nor-

bert Bender, and William Graham. The U. S. Naval Underwater Sound Laboratory acoustic studies are carried on by Elton P. Kelley and Edward G. Democh. Donald Gerson conducts the study of the Hydrographic Office on the differential movement of ice floes. The University of Alaska Earth-current and aurora observation program will begin when the station personnel are rotated in September.

The drift of the floe will be determined by taking navigational fixes by means of theodolite and chronometer. To obtain accurate location under the overcast conditions which prevail during summer, a radio theodolite, developed by the Collins Radio Co., has been installed. This instrument is able to track the Sun through the overcast. An added advantage of the instrument is that a continuous record of the drift can be obtained and the short-period variations in ice movement may be observed.

The first scientific report filed by Station Scientific Leader Kenneth O. Bennington, on June 1, 1959, states that the station has drifted northwestward at a rate of about two nautical miles per day. This is probably a rather rapid drift for this part of the Arctic Ocean in the early spring season. It may be expected as the summer melt and ice break-up advances the rate of drift will increase. The station may drift to the vicinity of the North Pole before the end of summer. The weather has been mild but there has been frequent fog and almost continuous cloud cover. The temperature, that ranged to −29°C when the construction party arrived on the ice, was averaging about −4°C by late May. Throughout the summer, with continuous sunlight, temperatures may be expected to range between −2°C and +1°C.

The ice runway is already beginning to deteriorate (1300 feet was unusable by mid-June), and soon the only contact with the outside world will be by radio and air drop until autumn when a new air strip can be built. At that time, personnel will be rotated and the station resupplied for the winter night.

Reference

Burkhanov, V. F., Soviet arctic research, *Priroda*, 5, 21–30, 1957; translated by E. R. Hope, Directorate of Scientific Information Service, DRB Canada, November 1957.

Reviews

HENRY STOMMEL, *The Gulf Stream, a Physical and Dynamical Description*, University of California Press, Berkeley and Los Angeles, xiii + 202 pp., 1958, $6.00.

This book on the description and theory of the Gulf Stream necessarily discusses aspects of the circulation of the entire Atlantic Ocean, which has features common to the Pacific and Indian Oceans; in effect, a large part of modern physical oceanography is covered. The first six chapters, on basic principles of oceanography and on history and descriptive features of the Gulf Stream, can be read without any special training. The remaining six chapters, on modern theoretical studies, involve physical and mathematical concepts of varying difficulty. "The purpose of this book is to describe and explain what is known about the Gulf Stream in a way which will interest physical scientists." I think the book will be of great interest to all oceanographers and has parts that will appeal to anyone wanting information about the Gulf Stream. The illustrations alone form a valuable and unique collection.

The theory of oceanic circulation has advanced markedly during the last twelve years, with Stommel playing a dominant role. Probably no one else enjoys such a broad comprehension of the how and why of ocean currents. Even with high expectation of the book, the reader is not disappointed. Stommel has frankly presented his own view and has thus achieved a unified, stimulating account of a highly complex subject. There is no other book that either contains so much description of the Gulf Stream or gives a view of the modern theories of oceanic circulation.

Although the book includes a comprehensive bibliography concerning the Gulf Stream, a few significant works are omitted. One is G. Dietrich's monograph concerning the pressure field in the Gulf Stream and the origin of Gulf Stream water (*Veröff. Inst. Meeresk. Univ. Berlin 33*, 1937). My calculation of summertime transport of the drift current is mentioned, but not the wintertime counterpart by E. M. Brooks (*J. Mar. Res.*, 2, 163, 1939). A. F. Spilhaus' pioneering studies of Gulf Stream eddies by use of bathythermograph and sea sampler can still be read with interest (*J. Mar. Res.*, 3, 51, 1940; *Trans. Amer. Geophys. Union*, 22, 478, 1941).

Fofonoff's paper on steady flow in a frictionless homogeneous ocean is mentioned briefly, but a more complete exposition with his maps of circulation patterns could well have been included. Fofonoff's model, though incomplete, shows the effect of inertial terms in a striking and simple manner and thus has an advantage over the complex studies by Charney and Morgan, which Stommel discusses at length.

The book is nicely produced, and I have noticed only a few misprints and other small errors. The first two equations on page 88 are reproduced unchanged from Stommel's famous paper of 1948 on westward intensification of ocean currents, and the first and last terms still lack a factor, density, which would balance the equations dimensionally. On page 108, potential vorticity is defined as $(f + \zeta)/D$, which is not dimensionally a vorticity and which departs from Rossby's definition, $(f + \zeta)(D_0/D) - f_0$. On page 158 the unit 10^8 g/sec/sec should be 10^{-8} g cm^{-2} sec^{-2}.

The preface is dated June 1955, and subsequent advances by Stommel and others are not included in the book. It is regrettable that the publisher delayed so many years. Nevertheless, the book is still fresh, the outstanding source of information on the Gulf Stream and the dynamics of ocean currents.

R. B. Montgomery

CARLOS G. BELL, JR. AND F. NEWTON HAYES, (editors) *Liquid Scintillation Counting*, Pergamon Press, xi + 292 pp., 1959, $10.00.

This book consists of papers presented at a conference on liquid scintillation counting held at Northwestern University in August 1957. These papers cover a wide range of subjects, including many techniques and various applications to chemistry, biology, physics, and geology.

Of greatest interest to Earth scientists are the discussions of the counting of low-level, low-energy natural radioactivities, in particular C^{14} and H^3. The promise of liquid-scintillation techniques for the counting of these radioisotopes arises from the possibility of incorporating the radioactive material into the scintillating liquid. This permits the counting of large samples in 4π geometry with a minimum of self-absorption. As indicated by the discussions in this volume, this promise is yet to be fulfilled.

This book is indicative of a trend toward publishing the informal discussions of scientific conferences in a format and at a price that one previously associated with a carefully written treatise. The papers vary greatly in quality, the terminology is inconsistent, and the lack of unity is emphasized by the absence of an index. While there is surely some value in presenting the proceedings of such conferences to the scientific public, it should be possible to do this in a less formal and expensive way. Few geophysicists will wish to add this book to their library, but those interested may profit from reading the papers on C^{14} and H^3 counting.

George W. Wetherill

List of Recent Books of Interest and Importance to Geophysicists

ABELSON, PHILIP H., ed., *Researches in Geochemistry*, Wiley, New York; Chapman and Hall, London, 521 pp., 1959, $11.00.

Technology in American Water Development,

ACKERMAN, EDWARD A., AND GEORGE O. G. LÖF, Johns Hopkins Press, 720 pp., 1959, $10.00.

ACTON, FORMAN S., *Analysis of Straight-Line Data*, Wiley, New York; Chapman and Hall, London, 280 pp., 1959, $9.00.

AMRINE, MICHAEL, *The Great Decision*, Putnam's, New York, 251 pp., 1959, $3.95.

BARNES, H., *Oceanography and Marine Biology*, Macmillan, New York, 218 pp., 1958, $7.00.

BRISER, ARTHUR, *Our Earth*, E. P. Dutton, New York, 123 pp., 1959, $3.25.

BENIOFF, HUGO, MAURICE EWING, BENJAMIN F. HOWELL, JR., AND FRANK PRESS (eds.), *Contributions in Geophysics*, vol. 1, Pergamon Press, viii + 244 pp., 1958, $9.00.

BERKNER, L. V., ed., *Manual on Rockets and Satellites*, vol. 6, *Annals of the International Geophysical Year*, Pergamon Press, xx + 508 pp., 1958, $25.00.

BRIDGMAN, P. W. *The Way Things Are*, Harvard Univ. Press, x + 333 pp., 1959, $5.75.

CABLE, E. J., R. W. GETCHELL, W. H. KADESCH, W. J. POPPY, AND H. E. CRULL, *The Physical Sciences*, Prentice Hall, 566 pp., 1959, $6.95.

CARSLAW, H. S., AND J. C. JAEGER, *Conduction of Heat in Solids*, Oxford Univ. Press, 520 pp., 1959, $13.45.

COLLINS, W. B., *The Perpetual Forest*, Lippincott, 1959, $4.50.

CONDON, E. U., AND HUGH ODISHAW (eds.), *Handbook of Physics*, McGraw-Hill, xxvi + 1504 pp., 1958, $25.00.

DASMAN, RAYMOND F., *Environmental Conservation*, Wiley, New York; Chapman and Hall, London, 318 pp., 1959, $6.50.

DILLINGER, JOSEPH R., (ed.), *Low Temperature Physics and Chemistry*, Univ. of Wisconsin Press, xxv + 676 pp., 1958, $6.00.

ETHERINGTON, HAROLD, (ed.), *Nuclear Engineering Handbook*, McGraw-Hill, xv + 1857 pp., 1958, $25.00.

FAITH, W. L., *Air Pollution Control*, Chapman and Hall, London; Wiley, New York, 266 pp., 1959, $8.50.

FANO, U., AND L. FANO, *Basic Physics of Atoms and Molecules*, Wiley, New York; Chapman and Hall, London, 429 pp., 1959, $10.00.

FANSELAU, G., *Moderne Probleme des Geomagnetismus Band III*, Verlag, Berlin, xii + 632 pp., 1959, 123 marks.

FELLER, WILLIAM, *An Introduction to Probability Theory and Its Application*, vol. 1, Wiley, New York; Chapman and Hall, London, xv + 461 pp., 1957, $10.50.

FINLAY-FREUNDLICH, E., *Celestial Mechanics*, Pergamon Press, viii + 150 pp., 1958, $7.50.

FLINT, RICHARD FOSTER, AND EDWARD S. DEEVEY, JR., *Radiocarbon Supplement* to the *American Journal of Science*, New Haven, vol. 1, 218 pp., 1959, $2.50.

FLÜGGE, S. (ed.), *Handbuch der Physik*, vol. 51, *Astrophysics*, II, Stellar structure, Springer, Berlin, viii + 830 pp., 1958, 175 marks.

FOURMARIER, P., *Hydrogéologie*, Masson, Paris; Vaillant-Carmanne, Liege, Belgium, 294 pp., 1958, 3000 francs.

FOX, JEROME, (ed.), *Proceedings of the Symposium on Electronic Waveguides*, Polytechnic Press, Brooklyn, 437 pp., 1958, $5.00.

GILLULY, JAMES, AARON C. WATERS, AND A. O. WOODFORD, *Principles of Geology*, W. H. Freeman and Co., San Francisco, 2nd ed., viii + 534 pp., 1959, $7.50.

GOODRICH, MAX, *Gravity and Interplanetary Travel*, Vantage Press, New York, 72 pp., 1958, $2.50.

HANSON, NORWOOD RUSSELL, *Patterns of Discovery*, Cambridge Univ. Press, x + 241 pp., 1958, $5.50.

HEEZEN, BRUCE C., MARIE THARP, AND MAURICE EWING, *The Floors of the Oceans*, vol. I, *The North Atlantic*, Geol. Soc. Amer., New York, 122 pp., 1959.

HEINRICH, E. WILLIAM, *Mineralogy and Geology of Radioactive Raw Materials*, McGraw-Hill, xiv + 654 pp., 1958, $14.50.

HICKS, TYLER G., *Successful Technical Writing*, McGraw-Hill, 305 pp., 1959, $5.50.

HIGGS, DONALD V., AND GEORGE TUNELL, *Angular Relations of Lines and Planes with Applications to Geologic Problems*, Wm. C. Brown Co., Dubuque, Iowa, v + 43 pp., 1959, $2.75.

HODGSON, JOHN H. (ed.), *The Mechanics of Faulting, with Special Reference to the Fault-Plane Work*, Dominion Observatory, Ottawa, vol. 20, 251–418, 1957, $3.00.

HOUGH, JACK L., *Geology of the Great Lakes*, Univ. of Illinois Press, xviii + 313 pp., 1958, $8.50.

HOWELL, BENJAMIN F., JR., *Introduction to Geophysics*, McGraw-Hill, xi + 399 pp., 1959, $9.00.

HYDE, MARGARET O., *Atoms Today and Tomorrow*, McGraw-Hill, 159 pp., 1959, $3.00.

JACKSON, J. D., *The Physics of Elementary Particles*, Princeton Univ. Press, ix + 135 pp., 1958, $4.50.

JEFFREYS, HAROLD, *The Earth*, Cambridge Univ. Press, 436 pp., 1959, $13.50.

JELLEY, J. V., *Cerenkov Radiation and Its Applications*, Pergamon Press, x + 304 pp., 1959, $10.00.

KARTSEV, A.A., Z. A. TABASARANSKII, M. I. SUBBOTA, AND G. A. MOGILEVSKII, *Geochemical Methods of Prospecting and Exploration for Petroleum and Natural Gas*, (English translation edited by Paul A. Witherspoon and William D. Romey)

Univ. of California Press, 349 pp., 1959, $12.50.

KEMENY, JOHN G., *A Philosopher Looks at Science*, Van Nostrand, 285 pp., 1959, $4.95.

KING, PHILIP B., *The Evolution of North America*, Princeton Univ. Press, 207 pp., 1959, $7.50.

KORZHINSKII, D. S., *Physicochemical Basis of the Analysis of the Paragenesis of Minerals*, translated from Russian by Consultants Bureau, New York, 142 pp., 1959, $7.50.

LANDSBERG, H. E., AND J. VAN MIEGHEM (eds.), *Advances in Geophysics*, vol. 5, Academic Press, x + 325 pp., 1958, $10.00.

LEIGHTON, ROBERT B., *Principles of Modern Physics*, McGraw-Hill, 807 pp., 1959, $7.50.

LOEBSACK, THEO, *Our Atmosphere* (translated from German), Pantheon, New York, 256 pp., 1959, $5.00.

MASSEY, H. S. W., AND R. L. F. BOYD, *The Upper Atmosphere*, Phil. Library, New York, 345 pp., 1959, $17.50.

MATHER, K. B., AND P. SWAN, *Nuclear Scatterings*, Cambridge Univ. Press, viii + 469 pp., 1958, $14.50.

McWHAE, J. R. H., P. E. PLAYFORD, A. W. LINDNER, B. F. GLENISTER, AND B. E. BALME, The Stratigraphy of Western Australia, Melbourne Univ. Press, 161 pp., 1958, $8.50.

MEHLIN, THEODORE G., *Astronomy*, Wiley, New York; Chapman and Hall, London, 400 pp., 1959, $7.95.

MONKHOUSE, F. J., *Landscape from the Air*, Cambridge Univ. Press, ix + 53 pp., 1959, $1.75.

MOORE, PATRICK, AND IRVING GEIS, *Earth Satellites*, Norton, rev. ed., New York, 157 pp., 1959, $3.95.

MOORHOUSE, W. W., *The Study of Rocks in Thin Section*, Harper and Bros., New York, xvii + 514 pp., 1959, $8.00.

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL, *Conference on Physical and Chemical Properties of Sea Water*, 211 pp., 1959, $2.00.

NEWELL, HOMER E., JR., *Sounding Rockets*, McGraw-Hill, vii + 334 pp., 1959, $12.50.

O'CONNELL, D. J. K., *The Green Flash and Other Low Sun Phenomena*, North Holland, Amsterdam; Interscience, New York, 192 pp., 1958, $6.00.

OPIK, ERNST J., *Physics of Meteor Flight in the Atmosphere*, Interscience, New York, viii + 174 pp., 1958, cloth, $3.85, paper $1.95.

ORR, CLYDE, JR., *Between Earth and Space*, Macmillan, New York, ix + 253 pp., 1959, $4.95.

PASCAL, PAUL, (ed.), *Nouveau Traité de Chimie Minérale*, vol. 11, group V, *Arsenic, antimoine, bismuth*, xxxix + 850 pp., 1958, 8950 francs; vol. 14, group VI, *Chrome, complexes du chrome, molybdène, tungstène, hétéropolyacides*, xxxix + 1014 pp., 1959, 10,700 francs, Masson, France.

POINCARE, HENRI, *The Value of Science*, Dover, New York, 147 pp., 1958, $1.35.

POPPER, KARL R., *The Logic of Scientific Discovery*, Basic Books, New York, 480 pp., 1959, $7.50.

PRYOR, EDMUND J., *Economics for the Mineral Engineer*, Pergamon Press, 254 pp., 1958, $6.00.

RICHTER, CHARLES F., *Elementary Seismology*, W. H. Freeman and Co., San Francisco, viii + 768 pp., 1958, $12.00.

ROBERTS, FRANK H. H., JR., (ed.), *River Basin Survey Papers*, Smithsonian Institution, Washington, D. C., 401 pp., 1958, $3.25.

ROUBAULT, MARCEL, Géologie de l'Uranium, Masson, Paris, 462 pp., 1958, $13.00.

ROUGH, FRANK A., AND ARTHUR A. BAUER, *Constitutional Diagrams of Uranium and Thorium Alloys*, Addison-Wesley, Reading, Mass., 159 pp., 1959, $5.00.

ROYAL ASTRONOMICAL SOCIETY and Others, *High Altitude and Satellite Rockets*, Philosophical Library, New York, 136 pp., 1959, $15.00 (12 papers presented at a symposium sponsored by Royal Aeronautical Society, British Interplanetary Society, and College of Aeronautics).

SARATOVKIN, D. D., *Dendritic Crystallization* (translated from Russian), Consultants Bureau, New York, 126 pp., 1959, $6.00.

SCOTT, RUSSELL B., *Cryogenic Engineering*, Van Nostrand, 379 pp., 1959, $5.60.

SCOTT, WILLIAM TAUSSIG, *The Physics of Electricity and Magnetism*, Wiley, New York; Chapman and Hall, London, 651 pp., $8.75.

SHAPIRO, IRWIN I., *The Prediction of Ballistic Missile Trajectories from Radar Observations*, McGraw-Hill, vi + 208 pp., 1958, $7.00.

SHTERNFELD, ARI, *Soviet Space Science* (translated from the Russian by the Technical Documents Liaison Office, Wright Patterson Air Force Base, Ohio), Basic Books, New York, 383 pp., 1959, $6.00.

SLUYS, ARIEN, *The Book of Nature*, Vantage Press, New York, 239 pp., 1959, $3.95.

SMITHSONIAN INSTITUTION, *Research in Space Science*, Special report no. 19, 20 pp.; Special report no. 20, 46 pp.; Special report no. 21, 37 pp., Astrophysical Observatory, Cambridge, Mass., 1959.

STANKA, VLADAS, *Institutions of the U.S.S.R. Active in Arctic Research and Development*, Arctic Inst. of North America, Washington, D. C., 100 pp., 1958.

STEPHENSON, RICHARD W. (compiler), *Selected Maps and Charts of Antarctica*, Library of Congress, Washington, D. C., 193 pp., 1959, $1.50 (processed).

STIRTON, R. A., *Time, Life, and Man*, Wiley, New York; Chapman and Hall, London, 569 pp., 1959, $9.00.

STOMMEL, HENRY, *The Gulf Stream*, University of California Press, Cambridge Univ. Press, xiii + 202 pp., 1958, $6.00.

SWINEFORD, ADA, (ed.), *Clay and Clay Minerals*, Pergamon Press, 422 pp., 1959, $8.50.

TODD, DAVID K., *Ground Water Hydrology*, Wiley, New York, xii + 336, 1959, $10.75.

TOULOUKIAN, Y. S. (general chairman), *Thermodynamic and Transport Properties of Gases, Liquids, and Solids*, McGraw-Hill, 481 pp., 1959, $12.50.

TREMAINE, MARIE, (ed.), *Arctic Bibliography*, vols.

6 and 7, Department of Defense, xiii + 1208 pp.; xiii + 1071 pp., 1957, $4.50, $4.25.

UNESCO, *Climatology and Microclimatology*, Paris, 355 pp., 1958, $11.00.

UNITED NATIONS, *Survey of Raw Material Resources*, vol. 2 of *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy*, Columbia University Press, x + 843 pp., 1958, $18.50.

U. S. NATIONAL COMMITTEE FOR IGY, *An Interim Bibliography on the International Geophysical Year*, National Academy of Sciences, Washington, D. C., 64 pp., 1959, $1.00.

VINOGRADOV, A. P., *The Geochemistry of Rare and Dispersed Chemical Elements in Soils*, 2nd ed., translated from Russian by Consultants Bureau, New York, 209 pp., 1959, $9.50.

VOOT, EVON Z., AND RAY HYMAN, *Water Witching U.S.A.*, Univ. of Chicago Press, 259 pp., 1959, $4.95.

WALFORD, LIONEL A., *Living Resources of the Sea*, Ronald Press, New York, xv + 321 pp., 1958, $6.00.

WATSON-WATT, ROBERT, *The Pulse of Radar: The Autobiography of Sir Robert Watson-Watt*, Dial Press, New York, x + 438 pp., 1959, $6.00.

WEEKS, K. (ed.), *Polar Atmosphere Symposium*, Pt. 2, Ionospheric section, Pergamon Press, xiii + 212 pp., 1957, $10.50.

WHITE, LESLIE A., *The Evolution of Culture*, McGraw-Hill, xi + 378 pp., 1959, $7.50.

WORRELL, ALBERT C., *Economics of American Forestry*, Wiley, New York; Chapman and Hall, London, 451 pp., 1959, $9.75.

Contents of Bulletin (Izvestiya), Academy of Sciences, U.S.S.R. Geophysics Series, January-April, 1958

Note—The March Issue of the *Transactions*, pages 28–31, listed the contents of *Izvestiya, Geophysics Series* for January-September, 1957. The June issue of the *Transactions*, pages 124 and 125, list the contents for October-December, 1957. Below are listed the contents for the four numbers, January-April, 1958. The production of the English edition of *Izvestiya* for 1957 was undertaken on behalf of the American Geophysical Union by Pergamon Press, with the aid of a grant from the National Science Foundation. Orders for sets ($25.00 plus a service charge of $3.00) should be sent to the American Geophysical Union.

The production of the twelve numbers issued in 1958 is being undertaken directly by the American Geophysical Union, with the aid of a grant from the National Science Foundation. Subscriptions for the volume, numbers sent as issued, are $25.00.

No. 1, January 1958

Reflected waves and head waves arising at a plane interface between two elastic media-II, N. V. Zvolinsky, 14 pp.

A ray method of computing wave-front intensities, V. M. Babich and A. S. Alekseev, 18 pp.

The distribution of elastic pulses in cylindrical specimens, O. I. Silaeva and O. G. Shabrina, 14 pp.

Basic notions of magnetohydrodynamics, S. B. Pikelner, 8 pp.

Determination of the gravity force at sea by the pendulum method, III, V. A. Romanyuk, 11 pp.

The modern conception of the thermal conditions of the Earth's crust, I. D. Dergunov, 10 pp.

Some ways of solving the direct problem of the aero gamma method, A. F. Yakovlev, 11 pp.

Measurement of temperature pulsations in the surface layer of the sea, N. V. Kontoboytseva, 7 pp.

Prognostic computations of AT-700 chart by electronic digital computer 'Strela,' A. U. Birkgan and A. N. Lubimov, 12 pp.

A boundary problem for an elastic halfspace, L. M. Flitman, 2 pp.

Fundamentals of a complex method of seismic zoning, S. V. Puchkov, 9 pp.

Accounting for the ellipticity of the Earth while determining the epicentral distances, M. N. Kolosenko, 5 pp.

An electrodynamic microbarograph with recording galvanometer, I. P. Pasechnik and N. E. Fedoseenko, 10 pp.

Effect of the atmospheric pressure on the tilting of the Earth's surface, V. V. Khorosheva, 5 pp.

Some results of electromagnetic sounding of geological structures, B. S. Enenstein and E. V. Rybakova, 2 pp.

Optical wave meter and range finder, S. P. Levchenko, 3 pp.

Book Review (T. Nagata, *Rock Magnetism*), 3 pp.

No. 2, February 1958

Boundary conditions for jumps in solutions of dynamic equations of the theory of elasticity with discontinuities, G. A. Skuridin and A. A. Gvozdev, 12 pp.

Intensities of longitudinal and transverse waves propagating at the boundary of a half-space, K. I. Ogurtsov and A. V. Burova, 8 pp.

Reflected and head waves originating at a plane interface separating two elastic media, III, N. V. Zvolinsky, 10 pp.

Displacements in the surface of a fracture, accompanied by slip, A. V. Vvedenskaya, 9 pp.

The dynamic features of totally reflected transverse waves, L. N. Malinovskaya, 12 pp.

Model experiments for studying the traversal of a head wave through a high-velocity layer, I. S. Parkhomenko, 14 pp.

Instrumental observations of weak earthquakes as a basis for the establishing of seismic regions, N. A. Vvedenskaya, 15 pp.
Some integral rules regarding the distribution of the gamma-field in layered media, R. M. Kogan, 10 pp.
The variation of the diffusion coefficient according to the Black Sea observations, V. V. Khlopov, 9 pp.
Influence of large topographic obstacles on the west-east current, G. P. Kurbatkin, 11 pp.
Errors in the determination of the coordinates of Crimean earthquakes, Z. I. Aronovich, 5 pp.
The dynamic parameters of some seismic foci in the Caucasus, N. K. Karapetyan, 9 pp.
The photographing of waves by using a grid, S. P. Levtschenko, 3 pp.
On the importance of eddies of different dimensions in the diffusion process, R. V. Ozmidov, 2 pp.
Determination of wind in a pressure field with account of vertical and horizontal mixing friction, A. F. Dyubyuk, 3 pp.
On the genesis of multilayered hailstones, I. V. Litvinov, 3 pp.
A universal formula for the rate of fall of a sphere in a fluid, K. S. Shifrin, 3 pp.
CHRONICLE, On the General Meeting of the International Union of Geodesy and Geophysics, 6 pp.

No. 3 ,March 1958

On the determination of the dynamic parameters of the hypocenter of an earthquake from records of surface waves, I, T. B. Yanovskaya, 13 pp.
The propagation of elastic pulses in free boundary layers of finite thickness, O. G. Shamina and O. I. Silayeva, 15 pp.
Study of the crystalline basement by the refracted-wave method under conditions of partial masking, I, Yu. I. Vassil'yev, O. I. Kovalev, and I. S. Parkhomenko, 13 pp.
The distribution of concentration of chlorine in atmospheric precipitation over a continent, T. K. Zhavoronkina, and A. A. Dmitriev, 7 pp.
Clouds in the stratosphere, A. Ya. Driving and A. I. Smirnova, 10 pp.
On electric charges in cloud particles, A. P. Sergiyeva, 11 pp.
The interpretation of the process of establishing an electric field in layered media, A. N. Tikhonov and O. A. Skugarevskaya, 5 pp.
Determination of the thermal coefficients by the method of a linear instantaneous source, D. N. Chetayev, 2 pp.
Choice of a method of measurement of an alternating electromagnetic field, O. M. Barsukov, 5 pp.
Theory of single electrode logging, I. K. Ovchinnikov, 4 pp.
Radio location method of signal accumulation and timing in geophysical prospecting, L. A. Khalfin, 5 pp.
On the impulse-interval acoustical logging, N. I. Khalevin, 8 pp.
A rectangular prism of constant susceptibility in a homogeneous magnetic field, Ye. N. Mokhova, 4 pp.
On the existence of convection currents in the mantle of the Earth, L. A. Latynina, 7 pp.
Processing of observations for earthquakes of Azerbaydzhan, Z. Z. Sultanova, 7 pp.
Equipment and methods used in recording turbulent microfluctuations of the temperature and current velocities in the sea, A. G. Kolesnikov, N. A. Panteleyev, Yu. G. Pyrkin, V. P. Petrov, and V. N. Ivanov, 9 pp.
On a theory of anticyclonic foehns, E. A. Burman, 5 pp.
Distribution of aerosol particles in the free atmosphere, A. G. Laktionov, 3 pp.
CHRONICLE, Conference on the problem of tsunamis and the seismicity of the Far East, 2 pp.

No. 4, April 1958

The mass determination of the coordinates of local earthquakes and of the velocities of seismic waves in the source areas, Yu. V. Riznichenko, 13 pp.
The absorption of elastic vibrations in rocks during stationary excitation, E. V. Karus, 11 pp.
The intensity of a head wave during its passage through a high-velocity layer, studied on models, I. S. Parkhomenko, 9 pp.
On the electrical conductivity and temperature of the Earth's mantle, V. N. Zharkov, 13 pp.
Transient processes in seismic prospecting apparatus, A. Ya. Melamud, 15 pp.
Propagation of tidal waves from a narrow into an open basin, S. S. Voyt, 11 pp.
Pressure variations in a baroclinic atmosphere, A. S. Monin, 18 pp.
On some characteristics of jet streams in the atmosphere, Kh. P. Pogosyan, 12 pp.
Variation of the electrical conductivity of air under different meteorological conditions, N. V. Krasnogorskaya, 9 pp.
Differential method of determining the depth of focus of a near earthquake, A. A. Treskov, 7 pp.
The North Baikal earthquake of April 29, 1917, S. L. Solovyev, 7 pp.
The distribution of remanent magnetization in cubes and cylinders of rocks, A. G. Kalashnikov, 4 pp.
The contact of river and sea water in the northwestern part of the Black Sea, V. S. Bolshakov, 4 pp.
Device for measurement of density and temperature by sounding at ultrasonic velocities in a strongly rarefied medium, G. A. Leykin, 2 pp.
The possibility of investigating aerosol layers by the twilight method, T. G. Megrelishvili, 4 pp.
Thermal equilibrium in the atmosphere, G. V. Gruza, 2 pp.
The screening effect produced by the surface layer of the Earth's crust during electric-prospecting for ore deposits, I. K. Ovchinnikov, 2 pp.

English Translations of Russian Scientific Journals and Papers

Many more translations of Russian scientific writings are available than is generally realized. In order to indicate what is available, the Office of Technical Services of the U. S. Department of Commerce has begun a semi-monthly publication entitled *Technical Translations* which lists translations not only from the Russian but from other languages as well available through various organizations in the United States, Canada, Great Britain, and Australia. Some of these are translations in full; others are abstracts of papers in journals, as indicated below. The following information is taken from Nos. 7 to 12 of Volume 1 of *Technical Translations* and from translations by the Directorate of Scientific Information Service, Defence Research Board, Ottawa, Canada, giving information bearing on subjects that are likely to be of special interest to geophysicists. The initials indicate sources from which translations may be obtained as follows: ATS, Associated Technical Services, Inc., P. O. Box 271, East Orange, New Jersey; CB, Consultants Bureau, Inc., 227 West 17th Street, New York 11, New York; DSIS, Directorate of Scientific Information Service, Defence Research Board, Ottawa, Canada; LC Photoduplication Service, Library of Congress, Washington 25, D. C.; MDF, Morris D. Friedman, Inc., Foreign Technical Translations, 67 Reservoir Street, Needham Heights 94, Massachusetts; OTS, Office of Technical Services, Department of Commerce, Washington 25, D. C.; SLA, SLA Translation Center, The John Crerar Library, 86 Randolph Street, Chicago 1, Illinois; mi, microfilm; ph, photostat.

Abstracts of Papers in Journals and Complete Journals

Geodeziya i Kartografiya (*Geodesy and Cartography*), no. 2, 5, and 6, 1958; OTS, $0.50 per copy, $6.00 per year.

Geokhimiya (*Geochemistry*), no. 3, 1958; OTS, $0.50 per copy, $4.00 per year. (This volume of this journal is being translated in full by the Geochemical Society; subscriptions, $20.00 for the 8 numbers comprising the volume, should be sent to the Geochemical Society, c/o Prof. E. Wm. Heinrich, Mineralogical Laboratory, University of Michigan, Ann Arbor, Michigan.)

Izvestiya, Akademiya Nauk USSR, Seriya Geofizicheskaya, (Bulletin, Academy of Sciences, USSR, Geophysics Series), no. 8, 1958; OTS, $0.50 per copy, $6.00 per year. (This volume of this publication is being translated in full by the American Geophysical Union; subscriptions, $25.00 for the 12 numbers comprising the volume.)

Meteorologiya i Gidrologiya (*Meteorology and Hydrology*), no. 3, 5, 6, 7, 1958; OTS, $0.50 per copy, $6.00 per year.

Complete Translations

Al'pert, Ya. L., E. F. Chudesenko, and B. S. Shapiro, Results of research on the outer region of the ionosphere, from observations of the radio signals of Sputnik 1 (with appendix by Ya. L. Al'pert, F. F. Dobriakova, Z. A. Malina, and Ye. P. Nesterova entitled Calculation of maximum distance of radiowave propagation in the optical geometric approximation, for a spherical earth; DSIS [Preliminary Results of Scientific Researches on the First Soviet Artificial Satellites and Rockets, no. 1, 40–108, 1958].

Andreyev, I. D., Accuracy of wind velocity measurements with the automatic recorded M-12; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 2, 45–46, 1958].

Baskin, M. L., and A. A. Semerchan, Growth and coalescence of crystals under the influence of ionizing radiations; DSIS [*Vestnik Akad. Nauk SSSR*, no. 1, 69–70, 1958].

Belousov, S. L., Short-range pressure forecasting using high-speed computers; LC or SLA, mi $1.80, ph $1.80 [*Tsentral'nyy Institut Prognozov, Moscow, Trudy*, no. 60, 10–16, 1957].

Blyumina, L. I., Weather forecast for seas for April 1958; OTS, $0.50 [*Dolgosrochnyy Prognoz Pogody (USSR)*, no. 4, 1958].

Bol'shakova, L. G., Yu. N. Georgiyevski, A. N. Otto, and S. F. Rodionov, Photoelectrometric study of the night sky luminescence; DSIS [(*Soviet*) *IGY Info. Bull.*, no. 4, 58–59, 1958].

Bonchkovsky, V. F., and R. M. Karmaleyeva, First results of the operation of an azimuthal inclinometer unit; OTS, $0.50 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 8, 1060–1063, 1957].

Bonchkovsky, V. F., and L. A. Latynina, A torsion deformograph; LC or SLA, mi $1.80, ph $1.80 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 3, 275–277, 1955].

Bryunelli, B. Ye., and D. A. Nizyayev, Magnetograph with visible recording; OTS, $0.50 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 8, 1064–1068, 1957].

Buchinsky, I. Ye. Meeting of the Section of Meteorology and Hydrology of the Scientific-Technical Council of the Main Administration of Hydrometeorological Service; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 2, 60, 1958].

Bylyeyev, N. I., and G. I. Marchuk, The numerical solution of equations of atmospheric dynamics; OTS, $0.50 [unknown source].

Chebotarev, A. I., and I. V. Popov, Third all-union hydrological sessions; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 2, 57–60, 1958].

Chudakov, A. Ye., Photon research conducted by means of the third artificial earth-satellite, [*Priroda*, no. 12, 88–90, 1958].

Driving, A. Ya., and A. I. Smirnova, Clouds in the

stratosphere; LC or SLA, mi $2.40, ph $3.30 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 3, 337–346, 1958].

DUMITRESCU, SORIN, Five years of activity of the main administration of hydrometeorology; OTS, $0.50 [*Meteorologia si Hidrologia*, no. 1, 5–10, 1956].

DYUBYUK, A. F., Determination of the wind through a pressure field in computing the friction of vertical and horizontal mixing; LC or SLA, mi $1.80, ph $1.80 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 2, 274–276, 1958].

FEDOROV, V. S., Method of regulation of weight on bit G_1 in turbodrilling; ATS, $8.15 [*Neftyanoye Khoz*, 36, no. 9, 14–17, 1958].

FEL'DSHTEIN, YA. I., AND YE. I. KURDINA, Magnetic variations in the region of the auroral zone; DSIS [*Problemy Arktiki*, no. 3, 53–59, 1958].

GAVRILOVA, V. M., The movement of cyclones to cold regions; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 4, 24–25, 1958].

GAYEVSKAYA, G. N., Conference of young specialists of the main geophysical observatory Imeni A. I. VOYEYKOV; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 2, 61, 1958].

GINDIN, YE. Z., G. A. LEIKIN, A. M. LOZINSKI, AND A. G. MASEVICH, Optical observations of the artificial earth-satellites; DSIS [*Preliminary Results of Scientific Researches on the First Soviet Artificial Earth Satellites and Rockets*, no. 1, 13–21, 1958].

GOROKHOVA, V. S., Some observations on a formula for correcting values of gravimetry observed at sea, conducted by V. A. Romanyuk; OTS, $0.50 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 11, 1402–1405, 1958].

GOTSADZE, O. D., V. I. KEYLIS-BOROK, AND OTHERS, Investigation of the mechanism of earthquakes; OTS, $3.50 [*Akademiya Nauk SSSR, Geofizichesky Institut, Trudy*, no. 40, 1–67, 1957].

GRECHUKIN, V. V., Results of industrial geophysical work in the Pechora coal basin; OTS, $0.50 [*Razvedka i Okhrana Nedr (USSR)*, no. 5, 43–51, 1957].

IL'INSKY, O. K., Conference on the regional synoptics of the Far East; OTS, $0.50 [*Meteorologiya i Gidrologiya (USSR)*, no. 3, 70–71, 1958].

KHAZOVA, O. N., Forecast of general weather characteristics for the Asiatic territory of the USSR for April 1958; OTS, $0.50 [*Dolgosrochnyy Prognoz Pogody (USSR)*, no. 4, 1958].

KOMAROV, V. D., Basic regularities of the distribution of the discharge coefficients of snow high water and the loss of thaw water in the thawing period in the European territory of the USSR; OTS, $0.50 [*Meteorologiya i Gidrologiya (USSR)*, no. 3, 28–33, 1958].

KVARATSKHELIYA, I. F., Properties of the changes with altitude of the yearly amplitudes of air temperatures over the southern regions of the USSR; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 4, 21–23, 1958].

LEONOV, N. G., Some characteristics of the wind change with altitude over eastern Atlantic shores, [*Meteorologiya i Gidrologiya*, no. 6, 8–13, 1958].

LOGINOVA, M. A., AND A. F. DYUBYUK, Certain problems dealing with large deformations of cylindrical casings; determination of wind and vertical velocity in areas of pressure using three equations of movement; OTS, $0.50 [*Moscow U. Vestnik*, no. 4, 29–40 and 125–128, 1957].

LYUSTIKH, YE. N., Isostasy and isostatic hypotheses; LC or SLA, mi $6.90, ph $21.30 [*Akademiya Nauk SSSR, Geofizichesky Institut, Trudy*, no. 38, 1–90, 1957].

MALOVICHKO, A. K., On the determination of the depth of a body according to gravitational and magnetic anomalies; OTS, $0.50 [*Razvedka i Okhrana Nedr*, no. 5, 57–58, 1957].

MASHKOVICH, S. A., Calculating the effect of nonlinear terms of equations in the solution of problems on the short-range forecast of pressure and temperature; LC or SLA, mi $2.40, ph $3.30 [*Tsentral'nyy Institut Prognozov, Moscow, Trudy*, no. 60, 22–31, 1957].

MERTSALOV, A. N., Nomogram for determining divergence and vortex; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 2, 48–51, 1958].

MEZHDUNARODNYY GEOFIZICHESKY GOD., SOVIET-BLOC IGY TRANSLATIONS; Contents: Draft of the interdepartmental plan for scientic processing of IGY data; Some problems in processing IGY materials; A. M. Lozinsky and A. G. Masevich, Optical observations of artificial earth satellites in the USSR; Instruction for the visual observation of artificial earth satellites; G. V. Bukin, Investigation of atmospheric ozone; V. D. Sokolov and G. V. Skripin, In the Yakutsk cosmic-ray laboratory; T. G. Megrelishvili and L. M. Fishkova, Investigation of upper-atmosphere luminescence; G. V. Bukin, Ionosphere observations at Vostok station; N. I. Grishin, Some results of observations of noctilucent clouds; G. K. Tushinsky and G. K. Sulakvelidze, Glaciological work on El'brus; V. F. Suslov, The expedition to the Fedchenko glacier in 1957; R. D. Zabirov, The present state of central Asian glaciers; Ye. I. Gal'perin, Study of the structure of the earth's crust in the transition zone from the Asiatic continent to the Pacific Ocean; A. D. Dobrovol'skiy, Maiden voyage of the Vityaz' under the IGY program; V. G. Bogorov, The second voyage of the Vityaz' under the IGY program; A. V. Nudel'man, In the relatively inaccessible region of the South Pole; In the Soviet IGY committee; LC or SLA, mi $7.20, ph $22.80 [*Mezhdunarodnyy Geofizichesky God. Informatsionnyy Byulleten' (USSR)*, no. 5, 3–81, 86–90, 102–111, 1958].

MIRKOTAN, S. F., AND L. A. DRACHEV, Phase-method study of large-scale inhomogeneities in the ionosphere; DSIS [*(Soviet) IGY Info. Bul.*, no. 4, 56–57, 1958].

MOLODENSKY, M. S., Basic problems of geodetic gravimetry; OTS; $2.25 [*Tsentral'nyy Nauchno-issledovatel'sky Institut Geodezii Aero'yemkii i Kartografii, Trudy*, no. 42, 1945].

MONIN, A. S., Preliminary characteristics of the zonal circulation of the atmosphere; OTS, $0.50 [*Akademiya Nauk, SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 10, 1250–1253, 1958].

MONIN, A. S., AND A. M. OBUKHOV, Small oscillations in the atmosphere and adaptations of meteorological fields; OTS, $0.75 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 11, 1360–1373, 1958].

NESMEYANOV, A. N., A great victory of Soviet science; DSIS [*Vestnik Akad. Nauk SSSR*, 28, no. 11, 3–9, 1958].

OZYABLOV, V. S., M. YA. DANILOVICH, AND G. V. SKVORTSOV, Experiment in deep drilling with air circulation under permafrost conditions; ATS, $10.15 [*Razvedka i Okhrana Nedr*, 24, no. 10, 45–58, 1958].

PANOV, D. G., Neotectonic movements in the Arctic region; DSIS [*Dok. Akad. Nauk*, 104, no. 3, 462–465, 1955].

PANOV, D. G., Tectonics of the central Arctic; DSIS [*Dok. Akad. Nauk*, 105, no. 2, 339–342, 1955].

POCHTAREV, V. I., The Earth, a great magnet; OTS, $2.25 [*Zemlya, Bol'shoy Magnit, Leningrad*, 1–86, 1958].

POGORELOV, V. I., Radar reflections from auroras; LC or SLA, mi $1.80, ph $1.80 [*Akademiya Nauk USSR, Izvestiya, Seria Geofizicheskaya*, no. 8, 1048–1051, 1958].

POGOSYAN, KH., Jet streams; OTS, $0.50 [*Grazhdanskaya Aviatsiya*, 15, no. 2, 33–36, 1958].

POGOSYAN, KH. P., Features of atmospheric circulation in the Antarctic; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 8, 3–10, 1958].

PREOBRAZHENSKY, A. I., The mineral wealth of the Soviet Union; LC or SLA, mi $2.40, ph $3.30 [*Geografiya v Shkole*, no. 5, 6–15, 1958].

REBINDER, P. A., L. A. SHREYNER, AND K. F. ZHIGACH, Hardness reducers in drilling: A physico-chemical method of facilitating the mechanical destruction of rocks during drilling; LC or SLA, mi $7.80, ph $25.80 [Monograph from Colloids-Electrochemical Inst., pub. by the Academy of Science, Moscow, 1944].

RIZNICHENKO, YU. V., B. N. IVAKIN, AND V. R. BUGROV, An ultrasonic pulse seismoscope; LC or SLA, mi $2.40, ph $3.30 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 1, 26–32, 1953].

RUDNEV, G. V., Conference of the chiefs of agricultural meteorological stations; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 4, 61–62, 1958].

SEN'KO, P. K., Unusual localized character of magnetic variation in the Mirny region; DSIS [*Informacionnyi Biulleten' no. 1 of the Soviet Antarctic Expedition*, 81–82, 1958].

SHATL', V. A., AND V. G. MORACHEVSKY, Active influence on the weather; OTS, $0.50 [*Priroda*, 47, no. 9, 85–88, 1958].

SHOKIN, P. F., Shifting of the null point of the SN-3 gravimeter as a result of inclination; OTS, $0.50 [*Akademiya Nauk SSSR, Izvestiya, Seriya Geofizicheskaya*, no. 11, 1399–1401, 1958].

STEPANOV, N. D., The agricultural meteorological service of collective farms, state farms and machine-tractor stations; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 4, 40, 1958].

USOL'TSEV, V. A., AND K. N. MANUYLOV, Basic features of the A-22-III radiosonde; OTS, $0.50 [*Nauchno-Issledovatel'sky Institut Gidrometeorologicheskogo Priborostroyeniya, Trudy*, no. 5, 3–16, 1957].

USPENSKY, B. D., Method for the determination of local acceleration in changes of geopotential heights of isobaric surfaces; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 3, 21–27, 1958].

VORONOV, P. S., Structural diagram of Antarctica; DSIS [*Informacionnyi Biulleten' no. 1 of the Soviet Antarctic Expedition*, 21–25, 1958].

YEVSEYEV, P. K., Distribution of showers and steady rainfall on the territory of the USSR; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 3, 13–20, 1958].

ZAMORSKI, A. D., Visual observations of artificial satellite; DSIS [*Priroda*, no. 11, 85–87, 1958].

UNAUTHORED, Bibliography on meteorology and hydrology for 1957; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 2, 53–56, 1958].

UNAUTHORED, Bibliography on Soviet artificial earth satellites; LC or SLA, mi $2.40, ph $3.30.

UNAUTHORED, General characteristics of expected weather in the European territory of the USSR and in western Siberia in April 1958; OTS $0.50 [*Dolgosrochnyy Prognoz Pogody (USSR)*, no. 4, 1958].

UNAUTHORED, Information on Soviet Bloc International Geophysical Cooperation, 1959; OTS, $12.00 per series.

UNAUTHORED, Literature in meteorology and hydrology during 1957: continuation; OTS, $0.50 [*Meteorologiya i Gidrologiya*, no. 3, 64–67, 1958].

UNAUTHORED, Soviet space effort—organization, equipment, objectives, and personnel; LC or SLA, mi $3.00, ph $6.30.

Notes and Personalia

Notes

SENIOR POSTDOCTORAL AND SCIENCE FACULTY FELLOWSHIPS—The National Science Foundation will make awards in various fields of science of the fellowships noted above. Applications should be received not later than October 5, 1959 by the Fellowship Section, Division of Scientific Person-

nel and Education, National Science Foundation, Washington 25, D. C. To be eligible, candidates must be citizens of the United States with special aptitude for advanced training, and must have held the doctoral degree for at least five years or have equivalent education and experience. Final selection of about 75 Fellows and annual stipends to a maximum of $12,000 adjusted to match as closely as feasible the salaried income of the recipients will be made by the National Science Foundation.

Graduate Fellowship Program of the National Science Foundation—As a means of promoting progress in science, the National Science Foundation plans to award approximately 1000 Cooperative Graduate Fellowships for the academic year 1960-61. This program is in addition to the Foundation's regular Graduate Fellowship Program and differs from that in that it provides for a broadened base of university participation, especially with respect to selection of Fellows for the program. The awards will be announced March 15, 1960. Selection will be made from among citizens of the United States solely on the basis of ability, in the 152 colleges and universities that are taking part in this program. Applications may be obtained from the Graduate Schools of the participating institutions or from the Fellowship Section of the National Science Foundation. Applications must be in the hands of the Dean of the Graduate School of the participating institution which the applicant expects to attend by November 6, 1959.

Foreign Field Research Program of the NAS-NRC—The fifth annual program of field research in foreign areas is planned for 1960 through the financial support of the Office of Naval Research. The first four years of this program permitted 37 American scientists to conduct field research in topics of their own choosing for periods ranging up to 20 months. The program is very broad in scope and includes not only all branches of geography, but closely related fields as well. It is designed primarily for graduate students who desire to conduct field research in connection with their doctoral dissertations, but post-doctoral scholars are also eligible. The extent of financial assistance will vary according to the needs involved. It is the plan to provide adequately for travel, field, and living expenses, but usually no stipend is provided. Recipients of support must agree to submit a report to the NAS-NRC for publication. Applications should be filed before December 1, 1959 with the Foreign Field Research Program, Division of Earth Sciences, 2101 Constitution Avenue, Washington 25, D. C.

Undergraduate Program of the National Science Foundation—More than 2000 undergraduates were given an opportunity during the summer of 1959 to participate in research directed by college and university faculty members under a program initiated by the National Science Foundation. Grants totaling $1,700,000 were given to about 200 colleges and universities widely scattered in the country. The purpose is to encourage research potentialities in undergraduate students. The program covers many phases of science including various facets of geophysics.

U. S. Government Awards Under the Fulbright and Smith-Mundt Acts—Announcement has been made of the availability of awards for university lectureships and advance research under the Fulbright and Smith-Mundt Acts. Inquiries should be addressed promptly to the Conference Board of Associated Research Councils, Committee on International Exchange of Persons, 2101 Constitution Avenue, Washington 25, D. C. Applications close October 1, 1959. Some 20 countries are involved in the program for 1960-1961.

National Science Foundation Grants for International Geophysical Cooperation 1959—The National Science Foundation has made 41 grants totaling almost $1,700,000 in support of the International Geophysical Cooperation Program that is continuing into the current year.

Gift to the National Academy of Sciences—The Equitable Life Assurance Society of the United States has made a gift to the National Academy of Sciences for the building of a new wing on the building of the NAS. This will be known as Equitable Life Assurance Society Hall of Life Sciences, and will be especially designed to house the scientific activities of the Academy-Council in its work relating to biology and medicine.

Symposium on Basic Research—A Symposium on Basic Research sponsored jointly by the Alfred P. Sloan Foundation, the National Academy of Sciences, and the American Association for the Advancement of Science, was held at the Rockefeller Institute in New York, May 14-16, 1959. Some 250 leading scientists, educators, and industrialists gathered for this occasion which was highlighted by an address by President Eisenhower, at which he announced plans for the two-mile long linear accelerator at Stanford University requiring an outlay of about $100 million. At each half-day session of the first two days three papers were presented to develop the theme of the session. The titles and authors of the first session were: "The Importance of New Knowledge" by J. Robert Oppenheimer, "Basic Research in the United States" by Alan T. Waterman, and "The Paradox of Choice" by William O. Baker. At the second session were presented "Basic Research and the Liberal Arts College" by Laurence M. Gould, "Basic Research and the State University" by Conrad A. Elvehjem, and "Basic Research and the Private University" by Lee A. DuBridge. At the third session were presented "Basic Research in Government Laboratories" by Allen V. Astin, "Basic Research in Industrial Laboratories" by James B. Fisk, and "Basic Research in Private Research Institutes" by Merle A. Tuve. At the fourth session were presented "Support of Basic Research from Government" by Paul E. Klopsteg, "Support of Basic Research from Industry" by Robert E. Wilson, and "Support of Basic Research from

Private Philanthropy" by Robert S. Morison. Following each group of papers a panel discussion was held involving the speakers, several others especially qualified to speak on the subject, and written questions from the floor. On the third day of the Symposium the panelists and a small number of participants continued deliberations. The papers and discussions will be published this coming autumn by the AAAS.

NEW WEATHER INFORMATION BOOKLET ON THE GREAT LAKES—The U. S. Weather Bureau has issued a booklet entitled *Climatology and Weather Services of the St. Lawrence Seaway and Great Lakes* which provides a summary of weather conditions found in the Great Lakes area and contains many tables and charts important to safe operation of vessels from Quebec to Chicago and Duluth. It contains 75 pages and may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. for $0.45.

PROGRAM ON WEATHER MODIFICATION—The National Science Foundation has recently announced a research program on weather modification involving 13 grants for laboratory research, field experiments, evaluation of present knowledge, and conferences on modern meteorological methods that may be useful in connection with weather modification. It is anticipated that a full story on this will be subsequently published in the *Transactions*.

THIRD CONGRESS OF THE WORLD METEOROLOGICAL ORGANIZATION—During the month of April the World Meteorological Organization held its Third Congress during a four-week period in Geneva, Switzerland. The Organization took a number of important actions, among these being the continuing use of artificial satellites to obtain weather information, new studies on atomic energy questions, efforts to fill the gaps in the world network of weather observation stations, as well as its routine but important matters relating to the program and budget for the next four years. The membership in WMO now includes 102 states and territories. Andre Viaut of France was reelected President, and David A. Davies of the United Kingdom Secretary General.

NATO OCEANOGRAPHIC RESEARCH CENTER—The North Atlantic Treaty Organization has established an international scientific center for research in oceanography at La Spezia, Italy, to be known as SACLANT Antisubmarine Warfare Research Center. This will be located at the Italian naval base and will cooperate with the Italian oceanographic research establishment nearby. The United States, as a prime mover, will aid in the establishment by providing $2½ million during the next two years. The new facilities will be devoted primarily to basic research rather than the actual development of antisubmarine weapons, with emphasis on comparatively shallow ocean areas such as are found in the Mediterranean and in other parts of the world.

RESEARCH INTO CAUSES OF TORNADOES—When the tornado struck Florida on June 17, 1959, announcement was made that the U. S. Weather Bureau is engaging in a tornado research project, noting that the prediction of the precise spot and the exact time that tornadoes will hit a community is one of the most difficult and challenging problems. Comprehensive research into the reason why severe thunderstorms suddenly develop tornadoes should pay large dividends in the saving of life and property. Research meteorologists are, however, still probing into causes of nature's tornado-generating processes in the hope that man may be able to deflect or destroy the tornado. Radar reconnaissance planes, unmanned storm-probing aircraft, and missiles probe the most turbulent areas between 5000 and 50,000 ft, and more complete surface and upper-air observation networks are required for a successful attack on this problem. It was noted that by June 18 of this year 300 tornadoes had been reported in the United States. In the entire year of 1958, 636 were reported; in 1957, 924.

TEMPERATURE-HUMIDITY INDEX—In response to the often mentioned comment, "It's not the temperature, it's the humidity," the Weather Bureau, recognizing that both temperature and humidity are measurably responsible for discomfort in hot weather, began the usage of what was called the Discomfort Index. This caused a furor in local communities, and Temperature-Humidity Index (THI) has been adopted instead. This is determined by adding the dry-bulb and wet-bulb temperatures Fahrenheit, multiplying by the factor of 0.4, and adding 15.

GRANT FOR ROCKET STUDIES OF SOLAR FLARES—The National Science Foundation has made a grant of $250,000 to the Naval Research Laboratory for rocket observations of ultraviolet and x-ray emissions from solar flares. Herbert Friedman, Superintendent of the Atmosphere and Astrophysics Division of NRL, is the principal investigator.

CONFERENCE ON INFORMATION PROCESSING—UNESCO sponsored a conference bringing together some 2000 scientists and mathematicians from 30 countries to consider the ways in which computing machines can be used more effectively in weather forecasts, and in the analysis of data in general. The Conference opened June 15.

SUBTERRANEAN HYDRAULICS IN ITS HISTORIC SETTING—A meeting of the Société Hydrotechnique is to be held in Nancy, France on: The general theory of the flow of subterranean fluids; Subterranean waters in agriculture; Subterranean waters in urban hydraulics; Evaluation of the resources of subterranean waters; Mineral waters; Subterranean waters in mines; Hydraulics of the layers of petroleum and of the reservoirs of gas; and Applications of radioactivity on subterranean hydraulics. Interested persons should get into touch with the Société Hydrotechnique de France, 199 Rue de Grenelle, Paris 7e, France. Technical abstracts of papers in three copies should be in the hands of the Society by October 31, 1959, and the complete report by February 29, 1960.

PUBLICATION PLANS OF THE *Journal of Research*—The *Journal of Research* published by the National Bureau of Standards in Washington has announced the separation into four sections available separately as follows: (A) Physics and Chemistry, six times annually, $4.00 ($4.75); (B) Mathematics and Mathematical Physics quarterly, $2.25 ($2.75); (C) Engineering and Instrumentation quarterly, $2.25 ($2.75); (D) Radio Propagation, six times annually, $4.00 ($4.75). The parenthetical rates are those for delivery outside of the United States. Orders should be sent to the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

SCIENTIFIC RESULTS OF THE MISSIONS OF THE SYNDICAT POUR L'ÉTUDE GÉOLOGIQUE ET MINIÈRE DE LA CUVETTE CONGOLAISE—These are published in *Annales du Musée Royal du Congo Belge, Série in-8°—Sciences géologiques*, Tervuren, Belgium, and are sold by the Librairie Van Campenhout, 95 rue de la Croix de fer, Brussels, Belgium. Some 15 volumes have already been published or are scheduled for early publication, the first being released in 1955. Persons interested may secure details by addressing the Royal Museum or the Librairie Van Campenhout.

DAILY TEMPERATURES OF THE SOUTH POLE—The daily maximum and minimum temperatures at the South Pole are now being received regularly at the National Meteorological Center at Washington, D. C., via U. S. Navy Communications. The Antarctic temperature messages are included on teletype circuits with the daily collections of reports of high and low temperatures in major cities of the United States. During the summer there have been differences of more than 200° F between temperatures in the United States and temperatures at the South Pole station.

RESEARCH GRANT IN OCEANOGRAPHY IN NOVA SCOTIA—The National Research Council of Canada has recently made the award of an annual grant of $90,000 to Dalhousie University in Halifax for the establishment of an Institute in Oceanography and for the provision of a staff and their operating needs. This grant will not be required for buildings or ships or major installations. Already extensive oceanographic activities have been carried out in the Halifax area and the Institute will provide a means for coordinating these as a more effective unit and integrate the new Institute into the educational program of Dalhousie University.

RESEARCH GRANT IN OCEANOGRAPHY IN BRITISH COLUMBIA—The Institute of Oceanography of the University of British Columbia has been awarded an annual grant of $90,000 by the National Research Council of Canada in addition to its present grants to enlarge its staff and facilities for research and teaching. The Institute is primarily concerned with the oceanography of the fjord-like inlets of British Columbia and the coastal waters of the Northeast Pacific. Applications for permanent or visiting staff appointments and graduate and postdoctoral fellowships are available. Inquiry should be sent to the Institute of Oceanography, University of British Columbia, Vancouver 8, B. C., Canada.

OCEANOGRAPHY AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY—Five staff members of the Woods Hole Oceanographic Institution have been appointed to part-time professorships in oceanography at the Masssachusetts Institute of Technology under the broad program for developing the Earth sciences at MIT. Those appointed are Columbus O'D. Iselin, Willem V. R. Malkus, Henry M. Stommel, William S. von Arx, and J. Brackett Hersey. This effort will involve a rotating plan by which the appointees will serve a term in residence at MIT to conduct courses in oceanography and supervise thesis research. The extensive facilities at Woods Hole will likewise be made available to students including opportunities to join ship expeditions. During the summer of 1959, nine graduate students from MIT worked at WHOI, five on fellowships awarded by WHOI.

INTERNATIONAL CONFERENCE ON WASTE DISPOSAL AT SEA—The University of California held on July 22-25, 1959, the First International Conference on Waste Disposal in the Marine Environment which included addresses by specialists and leaders in this field including public health, effects on marine biota, nearshore oceanography, and estuarine hydrography. Cooperating agencies were the World Health Organization, U. S. Public Health Service, U. S. Fish and Wildlife Service, National Institutes of Health, National Park Service, U. S. Coast and Geodetic Survey, Corps of Engineers, U. S. Army, and various groups from California.

CONTROL OF LIGHTNING—The U. S. Weather Bureau, in cooperation with the U. S. Forest Service, is engaged in the study of the control of lightning, noting that 7500 forest fires are started in the United States every year destroying resources valued at about $25,000,000. The largest problem is in the West, where rains that put out the fires frequently do not accompany the thunderstorms. Project Skyfire has been conducted in the Missoula, Montana, area for several years, and progress has been made to the point that under certain conditions the cloud form and its electric field may be modified. Feeding silver iodide or dry ice into the cloud base is possibly of aid in keeping the clouds from building up to the point of high potential, at the same time possibly increasing the amount of rain reaching the ground.

NEW MAP OF MALASPINA GLACIER—A map of Malaspina Glacier which covers 800 square miles in southern Alaska has recently been released by the U. S. Geological Survey; price of $0.75.

EIGHTH NATIONAL CLAY CONFERENCE—The Eighth National Clay Conference will be held at the University of Oklahoma on October 12-15, 1959. In addition, there will be a field trip either on October 11 or October 15 to the Wichita Mountains in southwestern Oklahoma. Inquiries concerning the Conference should be addressed to C. G. Dodd, Chairman, Eighth National Clay Conference, University of Oklahoma, Norman, Oklahoma.

NSF Supports Scientific Publications—The National Science Foundation has intensified its program to assist in scientific publications, and during the calendar year 1958 made a total of 51 grants—in the first quarter of 1959 this has increased nearly fourfold over the same period for 1958, the total for 1958 being $109,300. The AGU has received substantial grants for aid in meeting its publication deficit, for publishing the *Journal of Geophysical Research*, and *Izvestiya (Geophysics Series)*, and only recently has received word of a grant for the publication of an English edition of four numbers of the *Trudy* series of the Geophysical Institute in Moscow.

Grant for the Study of the Feasibility of a Telescope in a Satellite—A project to study the feasibility of installing a large telescope in an Earth satellite is being undertaken by the Kitt Peak National Observatory near Tucson, Arizona, under a National Science Foundation grant of $160,000. There is great interest in putting a telescope into orbit in order to take observations above the Earth's atmosphere. This should view planets and stars with unprecedented clarity. Preliminary engineering considerations indicate that the telescope might have a 50-inch aperture and a functioning lifetime of five to ten years. Aden B. Meinel, Director of the Kitt Peak National Observatory, is in charge of the investigation.

Inauguration of New President at the University of Hawaii—Laurence Hasbrouck Snyder was inaugurated as the sixth President of the University of Hawaii on February 17, 1959. Thomas S. Austin of the Biological Laboratory there served as AGU's representative.

Expedition Monsoon—The Scripps Institution of Oceanography Expedition Monsoon is scheduled to cover the interval from February to August 1960, using two ships to study the western Pacific and eastern Indian Oceans. Its scientific program will be similar to that of Expedition Capricorn, 1952-53, and Expedition Downwind, 1957-58, except that it will be in a different area. The ships will carry out bathymetric, sonoprobe, seismic-refraction, magnetic, heat-flow, bottom-sampling, bottom-photography, hydrographic, and gravity reconnaissance observations. CO_2 observations in the atmosphere and near-surface water will also be made, and large-volume water sampling and radioisotope and trace-element studies will be carried out especially in the northern part of the west Pacific and Indian Ocean areas. It is anticipated that the observations will be carried out along a track of more than 50,000 miles.

Ozone Studies—An expanded cooperative network of seven stations for the measurement of ozone has been announced by the U. S. Weather Bureau in cooperation with the Air Force, the Navy, and the Atomic Energy Commission. Five stations are now in operation at Caribou, Maine; Green Bay, Wisconsin; Bismarck, North Dakota; Washington, D. C.; and at Mauna Loa Observatory, Hawaii. New stations will be established at Nashville, Tennessee, and Fort Worth, Texas. Observations are also being taken at the South Pole.

New Research Vessels of the USSR—Two new oceanographic research vessels of the USSR, the *Voeikov* and the *Shokalsky*, are being commissioned in 1959 and will make their maiden voyages in the Pacific. Also, the Soviet submarine *Severyanka* has been converted to conduct research primarily for the fishing industry. Facilities will include underwater television equipment, echo sounders, and means for determining salinity, illumination, temperature, rate of flow.

Pacific Science Congress—The Tenth Pacific Science Congress will be held at the University of Hawaii in Honolulu, August 21 to September 2, 1961. Following the Congress there will be a field trip to the Island of Hawaii.

Meeting of Oceanographers in Saigon—Marine scientists from the east and southeast Asian countries met early in 1959 in Saigon to lay plans for cooperation of the studies of the seas in that region. The meeting was called by the UNESCO Science Cooperation Office for South East Asia. The tentative plans involve a survey of the ocean area lying between Taiwan, Sumatra, and the northern coast of Australia where the ocean currents reverse their direction periodically under the influence of monsoons. Very little data have so far been assembled on the related phenomena.

Desert Cultivation in the Negev—The problem of bringing the desert lands under cultivation is under investigation by the Beersheba Desert Research Institute in Israel. Three main phases are being studied: (1) the discovery and the acclimatization of useful plants that will grow in desert areas; (2) the utilization of solar energy; and (3) the demineralization of brackish waters. The work involves not only agriculture, but also meteorology, hydrology, and soil erosion as well, and is being coordinated by the American Institute for Plant Ecology with work in progress in desert areas in the United States, Mexico, Australia, and North and South Africa.

Effect of Smog on Plants—Some leafy vegetables such as spinach, romaine, endive, and celery show characteristic lesions which appear as a bronzing under the influence of smog according to a report made to the World Health Organization. Suggestions have been made that plants might be used as alarm signals in relation to air pollution.

Intergovernmental Conference on Oceanographic Vessels—The Conference convened by UNESCO will meet in 1960 in Denmark to discuss the operation of international oceanographic vessels and the institution of an international program of research and of training personnel in marine sciences.

Personalia

PHILIP H. ABELSON, Director of the Geophysical Laboratory of the Carnegie Institution of Washington, was elected to membership in the National Academy of Sciences during the spring meeting of the Academy.

HAROLD M. BANNERMAN of the U. S. Geological Survey has recently been given the Distinguished Service Award by the Department of the Interior.

LLOYD V. BERKNER, President of Associated Universities, Inc., and President of the American Geophysical Union, has recently been awarded two honorary doctorates; one by Columbia University and the other by the University of Edinburgh, Scotland.

TOM WILKERSON BONNER, Professor of Physics at Rice Institute, was elected to membership in the National Academy of Sciences during the spring meeting of the Academy.

DETLEV W. BRONK, President of Rockefeller Institute and the National Academy of Sciences, was recently awarded an honorary doctorate by the University of California at La Jolla.

NORMAN H. BROOKS of the California Institute of Technology at Pasadena, has been designated the winner of the Collingwood Prize for Juniors of the American Society of Civil Engineers for his paper *Mechanics of Streams with Movable Beds of Fine Sand*. He has also been awarded the John C. Stevens Award for his closing discussion to the same paper.

EDWARD CRISP BULLARD, Assistant Director of Research, Department of Geodesy and Geophysics, University of Cambridge, has been elected a Foreign Associate of the National Academy of Sciences at its spring meeting.

S. WARREN CAREY of the University of Tasmania has taken up duties as Visiting Professor of Geology at Yale University.

VEN TE CHOW, Professor of Hydraulic Engineering at the University of Illinois, has been named as an Engineering Consultant by the Mayor and Board of Supervisors of the City and County of Honolulu, to review the design criteria for the drainage and flood control projects to be developed on the Island of Oahu, Hawaii.

PRESTON E. CLOUD, JR., of the U. S. Geological Survey has recently been given the Distinguished Service Award by the Department of the Interior.

LEO O. COLBERT, U. S. Coast and Geodetic Survey, retired, has recently been given a military engineering achievement award by the Society of American Military Engineers.

Z. FRANKENBERGER DANES has taken up duties as Research Engineer with the Space Physics Branch, Systems Management Office Division of Boeing Airplane Company in Seattle, Washington.

FARRINGTON DANIELS has recently retired as head of the Department of Chemistry at the University of Wisconsin, but will continue to be active in solar-energy research. The Rockefeller Foundation has recently made a grant of $250,000 to continue this research. He has been connected with the University of Wisconsin since 1920.

GEORGE F. DARROW has recently resigned his position as District Manager for William Ross Cabeen and Associates and has opened his own office as a Consulting Petroleum Geologist in Billings, Montana.

H. R. DREW of Fort Worth, Texas, has recently been elected Executive Vice President of the Texas Atomic Energy Research Foundation. The Foundation was organized in April 1957 by 11 electric utility companies operating in Texas for the purpose of unifying their individual efforts in the development of nuclear energy.

ROBERT D. FLETCHER, Director of Scientific Services of the Air Weather Service, has been named to one of the new Research Advisory Committees of the National Aeronautics and Space Administration.

JAMES GILLULY of the U. S. Geological Survey has recently been given the Distinguished Service Award by the Department of the Interior.

LAURENCE M. GOULD, President of Carleton College, has been awarded an honorary doctorate by Dartmouth College.

NORMAN A. HASKELL, physicist with the Air Force Cambridge Research Center, recently presented the Guenter Loeser Memorial Lecture in Boston on the subject, "The Detection of Nuclear Explosions by Seismic Means."

RICHARD HAZEN of the consulting engineering firm Hazen and Sawyer, has been appointed a consultant to the Council on Engineering Affairs of Manhattan College. The College is engaged in designing a new program consisting of curricula in chemical, civil, electrical, and mechanical engineering, with increased emphasis on the humanities.

EARL INGERSON, formerly with the U. S. Geological Survey but currently at the Department of Geology, University of Texas, has recently been given the Distinguished Service Award by the Department of the Interior.

ROMAN K. C. JOHNS has left his position with the Laboratory for Electronics, Inc., and has taken up duties with Baird-Atomic, Inc. as a specialist in geophysics and astronomy. His headquarters will be in Cambridge, Massachusetts.

EDWARD J. KILCAWLEY, Professor and Head of the Division of Soil Mechanics and Sanitary Engineering at Rensselaer Polytechnic Institute, has been appointed a member of the New York State Air Pollution Control Board.

HARVEY B. KINNISON, formerly of the U. S. Geological Survey, has been given posthumously the Distinguished Service Award by the Department of the Interior.

KONRAD B. KRAUSKOPF of the U. S. Geological Survey was elected to membership in the National Academy of Sciences during the spring meeting of the Academy.

EMMETT M. LAURSEN of the Institute of Hy-

draulic Research of the University of Iowa, has recently been awarded the Karl Emil Hilgard Hydraulic Prize of the American Society of Civil Engineers for his paper entitled *Sediment-Transport Mechanics in Stable-Channel Design*.

FINLEY B. LAVERTY has recently been designated Assistant Chief Engineer of the Los Angeles Flood Control District in charge of the Dams and Construction Branch.

CHARLES H. LEE, Consulting Engineer of San Francisco, has formed a consulting partnership with Michael Praszker under the firm name Lee and Praszker. They will specialize in soil mechanics, foundation engineering, and applied hydrology.

THOMAS S. LOVERING of the U. S. Geological Survey has recently been given the Distinguished Service Award by the Department of the Interior.

C. R. MAIERHOFER, Chief of the Office of Drainage and Groundwater Engineering of the Bureau of Reclamation and a member of the Executive Committee of the U. S. National Committee of the International Commission on Irrigation and Drainage, has been designated Chairman of the Executive Committee.

KIRTLEY F. MATHER, Professor Emeritus of Geology at Harvard University, has been reelected President of the American Academy of Arts and Sciences for another year.

DONALD H. MENZEL, Director of Harvard College Observatory, has been appointed Vice President of the Geophysics Corporation of America and will head the newly formed Astronomics Division.

DAVID H. MILLER has resigned his work on research administration in physical climatology and physical geography in the Quartermaster's Research and Engineering Center at Natick, Massachusetts, and has taken up full-time research duties with the California Forest and Range Experiment Station. His current research emphasizes radiation and heat-balance concepts in the hydrologic studies of the Experiment Station.

JOHN NORTHROP, Geologist for the Hudson Laboratories of Columbia University, has been designated Chief Scientist on the Navy's largest and newest oceanographic vessel, the *Gibbs*, during the AMSOC-Moho cruise off Puerto Rico. The *Gibbs* is conducting seismic refraction and reflection surveys in cooperation with the research vessels *Bear*, *Vema*, and *Hidalgo*.

MORROUGH P. O'BRIEN, Dean of the College of Engineering of the University of California at Berkeley, has recently retired after serving the University since 1928. He became Dean in 1943.

MARTIN A. POMERANTZ, who has served as Senior Staff Scientist of the Bartol Research Foundation for more than 20 years, has been named the second Director of the Foundation.

FRANK PRESS, Director of the Seismological Laboratory, California Institute of Technology, has been named Chairman of the Defense Department's Special Committee on Seismology to review the proposed program in seismology outlined in the paper on pages 212-221 of this issue of the *Transactions*.

F. W. REICHELDERFER, Chief of the United States Weather Bureau and Vice-President of AGU, has recently received an honorary membership in the Society of Airway Pioneers for his outstanding service.

JOHN RODGERS, Associate Professor of Geology at Yale University, has been awarded a postdoctoral fellowship by the National Science Foundation and is on a year's leave for study in France and Switzerland.

RICHARD J. RUSSELL, Dean of the Graduate School at Louisiana State University, was elected to membership in the National Academy of Sciences during the spring meeting of the Academy.

A. NELSON SAYRE of the U. S. Geological Survey, and General Secretary of AGU, has recently received the Department of the Interior's Distinguished Service Award.

PAUL B. SEARS, Chairman of the Conservation Program at Yale University, was recently awarded an honorary doctorate by Wayne State University.

JOHN A. SIMPSON of the Argonne National Laboratory was elected to membership in the National Academy of Sciences during the spring meeting of the Academy.

MORTON J. STOLLER, formerly Assistant Chief of the Instrument Research Division of Langley Aeronautical Laboratory, has been appointed Chief of Space Science Projects in the Office of the Assistant Director for Space Sciences of the National Aeronautics and Space Administration.

OTTO STRUVE, who has been a Professor of Astronomy and Director of the Leuschner Observatory at the University of California since 1950, has taken up the duties of the first Director of the National Radio Astronomy Observatory at Green Bank, West Virginia.

W. F. G. SWANN, Director of Bartol Research Foundation of The Franklin Institute, has recently retired after 32 years as the first Director of the Foundation.

James A. VAN ALLEN, Head of the Department of Physics at the State University of Iowa, was elected to membership in the National Academy of Sciences during the spring meeting of the Academy. He has also been awarded an honorary doctorate by Cornell College.

STEPHEN S. VISHER, Professor of Geography at Indiana University, has recently been given the Outstanding Achievement Award of the Association of American Geographers.

THEODORE VON KARMAN, Chairman of the Graduate School of Aeronautics of California Institute of Technology, was recently awarded an honorary doctorate by Wayne State University.

FRED L. WHIPPLE, Director of the Smithsonian Astrophysical Observatory, was elected to membership in the National Academy of Sciences during the spring meeting of the Academy.

WALTER T. WILSON has been transferred from the Hydrologic Services Division of the U. S.

Weather Bureau to the U. S. Study Commission, Southeast River Basins, with headquarters in Atlanta.

R. G. Hoiles, geophysicist and geological engineer in Canada, was killed in an airplane accident October 10, 1958 at the age of 44. He was born at Maple, Ontario, and took his baccalaureate degree and master's degree from Queens University in 1940 and 1941, respectively. In 1943 he took his doctorate in geology at the University of Arizona. He began his career in magnetic and electrical surveys and continued on the geological interpretation of geophysical data until the time of his death. He became a member of AGU in 1948.

Ivan R. Tannehill, Assistant Chief of the Weather Bureau, retired, died May 2, 1959 in Frederick, Maryland, at the age of 69. He was born at McConnelsville, Ohio, and took his baccalaureate degree from Denison University in 1912. He began work with the Weather Bureau in 1914, and after service in the Aviation Section and the Coast Artillery of the Army during World War I and in the years following, he rejoined the Weather Bureau in 1922. In 1955 he was granted an honorary doctorate by his alma mater. He had been a member of AGU since 1935.

Jack Montgomery Terry, District Engineer for the U. S. Geological Survey with headquarters in Denver, died November 30, 1957 at the age of 51. He was born at Altus, Oklahoma. He took his baccalaureate degree from the University of Texas in 1930, immediately entering upon duties with the U. S. Geological Survey on its water resources studies. His entire professional career was devoted to stream-gaging work. He became a member of AGU in 1936.

Austin W. Zingg, Chief, Watershed Technology Research Branch, Agricultural Research Service, Department of Agriculture, died in Fort Collins, Colorado, on April 7, 1959 at the age of 52. He was born in Winfield, Iowa, and received his baccalaureate degree from Iowa State College in 1930. He continued graduate studies intermittently at various universities and received his master of science degree from Kansas State College in 1952. He undertook duties with the U. S. Department of Agriculture in 1934, had been engaged in various phases of soil and water conservation research continuously since that time, and had attained international reputation as an authority on the mechanics and control of wind and water erosion. He became a member of AGU in 1942.

Union, Section, and Committee Activities

Minutes of Executive Committee Meeting, American Geophysical Union

First Session, May 3, 1959

The meeting was called to order at 14h 07m in the Board Room of the National Academy of Sciences—National Research Council Building, 2101 Constitution Avenue, Washington, D. C., by President Maurice Ewing.

Present—P. H. Abelson, Wm. C. Ackermann, L. T. Aldrich, Leroy R. Alldredge, W. W. Atwood, Jr., K. Hilding Beij, L. V. Berkner, Walter H. Bucher, J. J. Capello, S. Douglas Cornell, Frank L. Culley, Earl G. Droessler, C. T. Elvey, Maurice Ewing, Irving Friedman, H. Richard Gault, H. H. Hess, Albert J Hoskinson, Floyd W. Hough, B. F. Howell, Jr., Patrick M. Hurley, W. C. Jacobs, H. R. Joesting, James N. Jordan, J. W. Joyce, Joseph Kaplan, Eugene C. LaFond, W. D. Lambert, H. E. Landsberg, Walter B. Langbein, Ray K. Linsley, John Lyman, Thomas F. Malone, Charles C. McDonald, Buford K. Meade, Walter H. Munk, L. M. Murphy, J. H. Nelson, J. A. Peoples, Jr., Charles Pierce, John C. Reed, A. N. Sayre, J. Frank Schairer, M. O. Schmidt, Alan H. Shapley, Waldo E. Smith, Victor Vacquier, E. H. Vestine, Charles A. Whitten, R. N. Wilson, and George P. Woollard.

Approval of minutes—The minutes of the Executive Committee meeting held on October 18, 1958, published in the December 1958 issue of the *Transactions* (pp. 1183–1197), were approved.

General Secretary's Report

The last report of the General Secretary is recorded in the minutes of the Executive Committee meeting of October 18, 1958, published in the December 1958 issue of the *Transactions* (pp. 1183–1187). There have been no changes in the Executive Committee membership in this interval.

Elections—Elections of officers of the Union including its eight Sections, the Pacific Southwest Regional Committee, the Pacific Northwest Regional Committee, and the North Central Regional Committee have taken place. A report on these elections will be presented shortly by James N. Jordan, new Chairman of the Committee of Tellers, who was appointed to succeed J. Hugh Nelson who resigned after he became a candidate for Secretary of the Section of Geomagnetism and Aeronomy.

Actions of Executive Committee by mail ballot—Since the last meeting of the Executive Committee ten actions have been taken by the Committee by mail ballot as follows:

Date	Subject	Approve	Disapprove
1958			
Oct. 30	Seventh list of proposed new members	40	0
Dec. 9	Proposed Corporation Member: Hughes Aircraft	41	0
Dec. 19	Ballot on Geodesy Conference (IAG) grant	38	0
Dec. 23	Eighth list of proposed new members	41	0
1959			
Jan. 15	First list of proposed new members	41	0
Jan. 30	Second list of proposed new members	41	0
Feb. 20	Third list of proposed new members	35	0
Mar. 6	Fourth list of proposed new members	38	0
Mar. 30	Proposed Corporation Member: Edward E. Johnson, Inc.	36	0
Apr. 7	Fifth list of proposed new members	37	0

Since the last meeting of the Committee, grants totaling $221,721 have been received from the National Science Foundation. The specific purposes for which the grants were made will be noted later in this report.

Publications—The new monthly *Journal of Geophysical Research* has been started. Nos. 1 to 4, inclusive (January to April, inclusive) have been distributed. No. 5 will probably be ready for distribution on schedule, about May 7, and No. 6 (June) is now in galley-proof stage. Editors P. H. Abelson and James A. Peoples, Jr., with the able assistance of Mrs. Rowena Peoples on the mechanics of editing and the aid of the AGU office on proofreading, are to be commended for their endeavor. Information concerning Nos. 1 to 4 is as follows:

January 1959
132 numbered pages of text plus 4 unnumbered pages, including 2½ pages of paid advertising; edition of 9400

February 1959
138 numbered pages of text plus 10 unnumbered pages, including 6 pages of paid advertising; edition of 9000
March 1959
128 numbered pages of text plus 10 unnumbered pages, including 3 pages of paid advertising; edition of 8800
April 1959
100 numbered pages of text plus 12 unnumbered pages, including 6½ pages of paid advertising; edition of 8800

The January 1959 issue was sent to all members in good standing, to all subscribers of both the *JGR* and the *Transactions* of 1958, and to all on the exchange list of both the *JGR* and the *Transactions* for 1958.

In the latter part of 1958 we published Nos. 5 and 6 of the *Transactions* of 1958 as follows:
October 1958
240 numbered pages of text plus 20 unnumbered pages, including 9 pages of paid advertising; edition of 6400
December 1958
218 numbered pages of text plus 14 unnumbered pages, including 7 pages of paid advertising; edition of 6400

Each of these two issues was made especially large in an effort to catch up on the backlog as much as possible and to avoid placing a burden of too many of the older papers on the new editors. The *Transactions* of 1959 are taking shape as a quarterly, and the first number (March) has been distributed (somewhat belatedly because of delays in the print shop). This was printed in an edition of 9200 and sent to all members and to all 1958 subscribers of both the *Transactions* and the *JGR*. It has 88 numbered pages of text plus 8 unnumbered pages including 1½ pages of paid advertising. This includes 48 pages of three numbers of the *IGY Bulletin* and a paper by J. Tuzo Wilson on his extended trip through Russia and the Chinese mainland last summer. The June issue of the *Transactions* is now at the printer's and will include two feature articles, one by Thomas Malone on the University Committee on Atmospheric Research (UCAR) and a summary story on the IGY by Sydney Chapman, as well as three numbers of the *IGY Bulletin*.

The last directory was published in the April 1957 issue of the *Transactions*. A reserve of $1300 was set aside in the last fiscal year and a similar amount in the current fiscal year for the publication of a new directory which we had hoped might be published this spring. Pressure of other matters, however, has precluded this, and the plans are now to include the new directory in the September issue of the *Transactions*. We are planning to modify the format on this occasion to take advantage of modern facilities for the preparation, publication, and maintenance of the list.

Advertising in both the *Transactions* and the *JGR* is not as voluminous as we had hoped by this time, but steps are being taken in an effort to increase the advertising sharply. An appeal is made to each of you to do what you can in this regard. We must recognize the fact that advertising in *JGR* or *Transactions* is rather on the order of prestige or public relations advertising such as one finds in many journals(for example, *Physics Today* and *Scientific American*). We must impress our friends who are corporation executives that the *JGR* as well as the *Transactions* are good media for public scientific relations advertising among scientists.

The Editorial and Publication Committee held its last meeting on November 20, 1958, and, in accordance with the revised Statutes and By-Laws, went out of existence. The Committee had done a commendable job in piloting the bimonthly *Transactions* from the inception of the *Transactions* as a bimonthly in 1945 through 1958, and is worthy of high commendation for its endeavors.

Merle A. Tuve has made a contribution of a complete bound set of the *Journal of Geophysical Research* to the American Geophysical Union; this has been placed in the hands of Editor Peoples in Kansas feeling that it would serve its greatest usefuness there inasmuch as sets are available in various libraries in the Washington area. Peoples has expressed great appreciation of having these, remarking that he feels the set is a real classic.

One of the actions of the Editorial and Publication Committee is now on the verge of bearing fruit in Geophysical Monograph No. 3 relating to the papers presented at the Conference on Atmospheric Chemistry of the Compounds of Chlorine and Sulfur held in Cincinnati in November 1957 in cooperation with the Robert A. Taft Sanitary Engineering Center of the U. S. Public Health Service. In the spring of 1958, an application for a grant was made to the National Science Foundation, which approved the grant of $3550, made to the National Academy of Sciences. The manuscript is now in the hands of the printer; delivery is scheduled for June 1. Pre-publication sales have not been as strong as for the previous monographs, and so it is probable that the full grant from the NSF will be needed to cover the cost.

In the meantime Geophysical Monographs Nos. 1 and 2 have continued to sell. Our stock of these is now, respectively, about 370 and 880.

The Committee on Atmospheric Chemistry initiated a plan for a conference on isotope techniques in atmospheric chemistry, but when it was learned that the American Meteorological Society is planning a session on this for their annual meeting next January, plans for our conference were dropped for the time being.

The Johnson Reprint Corporation, about a year ago, completed the reprinting of volumes 1, 2, 4, and 6 to 12, inclusive of our *Transactions* (volumes 3 and 5 contained no scientific papers and consequently were released only in mimeograph form),

and are about to complete Nos. 13, 14, and 15. We receive a 15% royalty on sales. For 1958 sales we received a payment of $1136. The sale of microcards by the Microcard Foundation brought in a royalty of about $68 for sales during 1958. On July 1, 1959, we expect to turn over the remainder of our 1956 numbers of the *Transactions* to Walter J. Johnson, Inc. M. A. Tuve made a similar arrangement with the Johnson Reprint Corporation concerning the first 63 volumes of *JGR* and has arranged that the AGU should receive 15% royalty from the sales of the reprinting of these.

Translation of *Izvestiya* for 1958 is moving along quite satisfactorily. A grant of $44,835 has been recieved to cover the work. W. S. Jardetzky has undertaken the work as translation editor, and has selected a translation panel of 12 or 15 to do the actual translating work and another group of consultants to assist in the working over of these translations in specific fields. No. 1 is in the hands of the printer; the translation of No. 2 is complete, and Nos. 3 and 4 are in progress. We hope that by late summer or early fall the volume for 1958 will be complete and we can begin with No. 1 of 1959.

Pergamon Press has completed Nos. 1 through 11 of *Izvestiya* for 1957 (excepting that they omitted the list of papers published in No. 10 from the inception of the periodical in the 1930's), and they have supplied us with a copy of the proof of No. 12. We hope that this work will be completed soon. We are working out arrangements to have the complete stock brought to this country as soon as the job is complete. We have received a supplementary grant of $16,036 from the NSF to cover the added costs of producing the translated volume.

The Murray Pess at Forge Village, Massachusetts, will undertake the offset printing of the numbers of *Izvestiya* for 1958 and have agreed to store the numbers for 1957, as well as 1958, without charge, but will make a charge for the filling of orders.

The Russian Translation Board (Perry Byerly, Chairman) will meet on the morning of May 3, 1959.

A new Geophysical Monograph Board has been established under the chairmanship of Alan H. Shapley. The Board plans to hold its first meeting during the Annual Meeting of AGU. Shapley will have opportunity to fill us in on details of the progress later in the Executive Committee meeting.

In accordance with previously announced plans we have discontinued exchanges with most of those on our list of about 200 inasmuch as they are no longer required for the compilation of our bibliography. Still continued on the list are the officers of the International Union of Geodesy and Geophysics and its Associations (about 20 or 25). In addition, however, Dr. Tuve has requested the continuation for a reasonable period of the exchange and free list that he maintained, and accordingly the 100 or so on his list are getting the *JGR* without charge. The General Secretary feels that steps be taken to formulate a new exchange policy both as it relates to the *JGR* and to the *Transactions*.

Erwin Schmid, formerly Editor for Geodesy, declined his honorarium totaling $150 for the calendar year 1958. In accordance with previous policy, this amount has been added to the Permanent Fund as a contribution from him.

It was agreed among the officers and set up in the budget and grant estimates that each editor would receive an honorarium of $2000 per year. Editor Abelson has not accepted his honorarium. The amounts which are payable quarterly are turned over to the Permanent Fund as contributions from him.

The mechanics of editing the *JGR* is actually being done in the home of Editor Peoples, who has turned the best bedroom in his home into an editorial office. It was agreed among the officers that a rental of $30 per month should be offered to him. During the quarter October to December 1958 he declined to accept this, and the amount has been added to the Permanent Fund as a contribution from him.

Membership—Membership data as of April 21, 1959, are:

Membership as of October 6, 1958.	5099	
Reactivated	3	
New members, October 6, 1958, to April 21, 1959, including 76 applications now being processed toward membership	825	5927
Resigned	104	
Inactive	5	
Dropped	10	
Deceased (reported since October 6, 1958)	19	138
Total April 21, 1959		5789

The up-serge in the membership has been largely because of the fact that some 35,000 application forms were sent out to the mailing list of the American Geological Institute in December 1958. We still plan to circularize the American Physical Society list.

Dues unpaid—As of April 21, 1959, the following dues were unpaid:

For 1959	523
For part of 1959	23
For 1958 and 1959	157
For part of 1958 and all of 1959	2

In addition, there are 130 persons who have not paid dues in full for 1957. According to the Statutes and By-Laws, these are hereby recommended to the Executive Committee to be dropped from membership, but with the usual added recommendation that one more effort be made to return them to active membership.

Deaths—The following 19 deaths have been reported to the office since our last meeting on October 18, 1958: L. James Bulkley (date un-

known); Luke A. Cole, September 2, 1957; Jack M. Terry, November 30, 1957; James B. Cullison, Jr., February 2, 1958; Heber B. Churchill, March 25, 1958; Mark R. Kulp, June 1958; A. L. McCuistion, July 9, 1958; E. J. Kolkmeyer, August 18, 1958; R. A. Bramkamp, September 1, 1958; W. W. Horner, September 22, 1958; Robert M. Overbeck, September 23, 1958; R. G. Hoiles, October 10, 1958; David Donoghue, October 15, 1958; William Schriever, November 20, 1958; Jackson H. Wilkinson, November 29, 1958; Thomas J. Mitchell, December 29, 1958; Carl Rohwer, January 14, 1959; Harvey B. Kinnison, March 14, 1959; Gerard H. Matthes, April 8, 1959.

Finances—The assets of AGU, as of April 1, 1959, are shown in the following accounts:

Riggs National Bank, checking account	$ 25,366
Riggs National Bank, savings account	55,926
U. S. Treasury Bills, mature Aug. 1959, mature value	20,000
U. S. Treasury Notes, mature May 1960	50,000
U. S. Series F Bonds	518
Interstate Building Association	9,996
Northwestern Federal Savings and Loan Association	9,900
Prudential Building Association	8,669
Eastern Building and Loan Association	10,000
Home Building Association	10,000
Enterprise Federal Savings and Loan Association	10,000
Total	$210,375[a]

Below is a statement of the allocation of our assets as of April 1, 1959, in comparison with the two previous years. Because of the great change in circumstances in 1959, the comparison is quite without meaning.

	Apr. 1, 1959[a]	Apr. 1, 1958	Apr. 1, 1957
Current balance[b]	$103,469	$39,402	$32,732
Permanent Fund	17,587	14,589	13,741
Emergency Fund	1,000	1,000	1,000
T. M. & E. Award Fund	1,386	1,311	1,268
Russian Translation Fund			
Izvestiya, 1957	14,945	32,477	.....
Izvestiya, 1958	41,414	.....	.....
Cloud Physics Conference	24,583	.....	.....
Conference on Contemporary Geodesy	5,991	.....	.....
Totals	$210,375	$88,779	$48,741

[a] Does not include $3550 NSF grant which was made for us to the NAS-NRC for the support of Monograph No. 3, nor the NSF grant of $4500 for the IAG Conference which had not been received on April 1.

[b] The total at this time of the year tends to give the wrong impression because most of our income for the year has been received and most of our expenditures are still ahead.

Since our last meeting we have received word from the National Science Foundation of a total grant to the extent of $146,000 over a five-year period, to be given to us as follows: January 1959 $75,000 (received), January 1960 $40,000, January 1961 $15,000, January 1962 $10,000, and January 1963 $6,000.

In December 1958 $2,500 of Series F U.S. Savings Bonds came due (cost $1,850, accumulated interest $650). This has been added to the Permanent Fund in the Prudential Building Association.

In accordance with the instructions of the Executive Committee, the funds of the Union not immediately needed have been placed at interest as follows: U.S. Treasury Notes maturing May 15, 1960, bearing about 3.6% interest, $50,000; U.S. Treasury Bills maturing August 6, 1959, bearing somewhat better than 3% interest, $20,000; transferred to Savings Account at Riggs National Bank, total now $55,926, bearing 3% on first $10,000 and 2% in excess of $10,000; new accounts entered in three building and loan associations of $10,000 each, bearing 3¾ to 4%.

The budget as approved at the last meeting of the Executive Committee and published in the December 1958 issue of the *Transactions* (pp. 1192–1193) is proving adequate in most regards. As a matter of fact, because the *JGR* has not been as bulky as we had anticipated, the expenditures for the publication of the new Journal have been less than estimated. On the other hand, advertising receipts have been much smaller than the budget contemplated. These two tend to offset each other, but with the generous grant from the National Science Foundation already in hand, which will be needed as the *JGR* develops, our cash position of regular funds is very good. The $2.00 increase in dues at the beginning of this year caused inappreciable increases in resignations, and because of the fact that many new applications for memberships were received, the resignations are much less conspicuous than usual.

The documents relating to the negotiable U.S. Treasury Notes and Bills are in safe storage with the Riggs National Bank, but it is necessary for us to make other provision for their safekeeping. This can be accomplished through the renting of a safe deposit box at the Riggs National Bank, but a resolution to this effect is required by the Bank.

Office staff—The office staff at the present time consists of three full-time employees, James J. Capello, Ethel G. Sanders, and Carol C. Akers. In addition, Glenda Quinn Olmstead, who has been with us for five years, is still working three to five days a week. Barry Modlin, who has been with us six years and is a student at George Washington University, works on the average about one day a week and will be with us again full time during the summer. Patricia J. Moore is a full-time worker from Antioch College for the interval

April to June 1959, inclusive. From about the middle of April to the first of June we have taken on a temporary secretary. Waldo E. Smith, Executive Secretary, continues in direct charge of the office.

Quarters—There has been no change in our present arrangement, but our lease expires as of June 30, 1959. A new lease is in hand calling for a basic rental increase from $4.00 per square foot per year to $4.75 per square foot per year. We plan to execute this lease through the National Academy of Sciences and continue in the same quarters.

International matters—The Committee on International Participation had a meeting on January 23, 1959. It is anticipated that Chairman Joyce will make an extended report relative to this.

An official invitation has been received from Finland (dated December 31, 1958) to the Twelfth General Assembly of IUGG to be held in Helsinki, July 25-August 6, 1960. This has been responded to appropriately by President Ewing, and copies of his letter were forwarded to the American Ambassador in Helsinki as well as to the Finnish Ambassador in the United States. It is noted that the invitation is from the Finnish National Committee.

Plans are going forward for the Twelfth General Assembly of IUGG, and already a substantial list of persons have had their names placed on the tentative list of those planning to attend. The office awaits word from others. The First Circular has been issued by the Finnish National Committee and will soon be forwarded to those on our tentative list.

One of the problems requiring particular attention is the situation of the geochemists, many of whom would like to have a home in the IUGG. A special committee under the chairmanship of J. Frank Schairer was designated informally at the time of the recent meeting of the Committee on International Participation, and he has been asked to report at this meeting.

In September 1958 the International Association of Hydrology held a meeting at Chamonix, France, on the physics of ice movement. Another meeting on forest influences in hydrology is scheduled to be held in Germany in 1959.

The International Association of Geodesy has organized a symposium on distance-measuring methods to be held in Washington, May 5-12, 1959. Detailed arrangements are in charge of C. A. Whitten, Vice President of this Association. For the traveling expenses of foreign participants, we received a grant of $4,500 from the National Science Foundation. Another meeting is to be held in Trieste, July 5-13, 1959, by the Permanent Commission on Earth Tides. Other meetings under the auspices of this Association include a symposium on three-dimensional geodesy at Venice, July 16-19, 1959, a meeting of the International Gravity Commission at Paris, September 15-19, 1959, and a symposium on European leveling at Liverpool, October 5-10, 1959.

Meetings—The Section of Geodesy arranged a Conference on Contemporary Geodesy with the aid of a grant of $6,800 from the National Science Foundation which was held at Harvard College Observatory, Cambridge, Massachusetts, December 1-2, 1958. Some 75 were in attendance. The papers and reports presented were very good, and plans have been laid with the aid of the grant to publish the results as Geophysical Monograph No. 4.

The Pacific Southwest Regional Group held its annual meeting at Stanford University, February 5-6, 1959, with more than 200 registrants. In due course some of the papers will appear in the *JGR*, and the abstracts of the papers are being published in the June 1959 issue of *JGR*.

The plans for our Annual Meeting May 4-7, 1959, are complete. The program includes about 215 papers, including some 68 in the joint sessions of the Section of Meteorology and the American Meteorological Society.

The Committee on Cloud Physics (Helmut Weickmann, Chairman) of the Section of Meteorology is arranging a second meeting (first one in 1955) at Woods Hole, Massachusetts, June 3-5, 1959, to which eight or ten scientists are being brought especially from foreign lands. The support of this is by means of a grant of $25,000 from the National Science Foundation, which covers not only the conference proper but includes funds for the publication of the results. It is anticipated that the results will be of high quality and that these can be published as Geophysical Monograph No. 5.

Note that there will be the usual meeting in the Pacific Northwest Region this coming autumn and in the Pacific Southwest Region in the winter. The American Association for the Advancement of Science has its meeting in Chicago between Christmas and New Year's this coming winter. W. C. Krumbein, one of our members on the Council of the AAAS, is working on plans for AGU sessions in connection with this. It is also likely that we will cosponsor various other sessions as seems appropriate.

Statutes and By-Laws—The Statutes and By-Laws as amended to date are being published in the June 1959 issue of the *Transactions*, the first publication since 1955.

Certain changes are being recommended in accordance with the suggestions of the Executive Committee at its last meeting. The Committee on Statutes and By-Laws will offer an addition to the Statutes of the Union to cover a general group of members referred to as Supporting Members. Their report also covers certain changes in the Statutes and By-Laws of the Pacific Northwest Regional Branch which the Committee recommends for approval.

American Geological Institute—The AGI has been helpful in circularizing their mailing list with respect to members and subscriptions. This has been greatly appreciated.

Miscellaneous—The American Association for the Advancement of Science adopted eight resolutions at its annual meeting last December, these

bearing respectively, on (1) Parliament of Science, (2) committees on the social aspects of science, (3) international scientific programs, (4) dissemination of Council resolutions, (5) agenda and resolutions committee for 1959, (6) international travel and communication, (7) control of nuclear weapons tests, and (8) Federal aid to education. A set of the resolutions has been received by the AGU for information. They have been published in *Science* (129, 471–472, Feb. 20, 1959).

Plans for the development of an Institute of Geophysics of Hawaii are again becoming active, and various members are being helpful in this connection. It is hoped that this session of Congress will pass the authorizing legislation to implement the NSF's plans in this regard. This Institute is badly needed. Suggestions have been made that this might appropriately be called the Geophysical Institute of the Pacific, being located near the middle of the Pacific basin.

The AGU has been represented officially at a number of functions including a conference called by Surgeon General Burney of Health, Education, and Welfare on ways and means by which the Public Health Service and various groups such as ours may work together more effectively to the mutual advantage of both groups. On behalf of AGU, this was attended by James P. Lodge, Jr., and the Executive Secretary.

William J. Powell, District Geologist of the U. S. Geological Survey at the University of Alabama, was designated as our representative at the inauguration of the new President of Howard College in Birmingham, Alabama. We received an invitation to send a representative to the inauguration of the new President of Northeast Louisiana State College, but because of the shortness of time we could designate no representative. Recently an invitation has come to the General Secretary for the AGU to designate a representative to the dedication of the Bronx Community College and the inauguration of Dr. Morris Meister as its President on May 11. Charles H. Behre, Jr., Chairman of the Department of Geology at Columbia University, has indicated his willingness to serve as our representative.

Calls are received almost daily from vocational guidance counsellors and other groups interested in the matter of education in geophysics which we meet in the best way that we are able. Usually these persons are referred to various career publications which, for the most part, do not treat geophysics in a satisfactory way.

The National Education Association is planning a conference to be held at Lawrence, Kansas. Athelstan Spilhaus, Frank C. Foley, and James A. Peoples, Jr., have been asked to represent AGU. At a similar conference in June 1958 held at Bowling Green, Ohio, the AGU was represented by John R. Coash, Paul M. Pepper, Howard J. Pincus, and C. Warren Thornthwaite, who found the meeting to be a challenge as indicated by the report published in the December 1958 issue of the *Transactions* (pp. 1197–1198).

We have received calls from the Civil Service Commission in the matter of position classification. These have been forwarded appropriately to officers of the Section concerned with the subject matter.

It is of interest to note that the American Meteorological Society has been given a Beacon Street mansion in Boston for its new headquarters. The historic house and stable are at 45 Beacon Street and were transferred to the Society by the Bulfinch House Trust. The job of restoration will be considerable, but the Society expects to occupy its new quarters in time for its annual meeting in January 1960.

A. NELSON SAYRE,
General Secretary

Action on the General Secretary's report—The report was accepted.

Action on recommendations in the General Secretary's report—The recommendation that the 130 persons who have not paid dues in full for 1957 be dropped from membership after making one more effort to return them to active membership was accepted.

A resolution was adopted relative to renting a safe deposit box in the Riggs National Bank subject to regulations required by the bank. All of the officers of the Union shall have access to the box, but at least two officers shall be present when the box is opened.

Since AGU has discontinued its bibliography, and since it does not maintain a library, AGU has little need for exchange publications. The exchange list of the Union was almost entirely foreign. In addition to the officers of IUGG the list included research institutions as well as foreign government agencies and totaled about 200 names. The recipients (except the officers of IUGG) were advised in the autumn of 1958 of our desire to discontinue the exchange arrangement. The former *JGR* had a free list and an exchange list, mostly foreign, of about 120, and M. A. Tuve has requested that these be continued for the present. This is being done except where the addresses are those of regular subscribers or of individuals who are members of AGU. With these deletions, Tuve's list contains about 100 names.

Some Committee members felt that an exchange list is a rather inexpensive and effective way of gaining and maintaining good will. Therefore, unless we consider ourselves as simply a society, with no responsibility beyond the membership, we should maintain an exchange list. Others felt that we should have the general overall policy of letting people and organizations pay for what is desired, but that our Journal should go without charge to qualified abstracting publications. Many groups that have considerable funds restrict their exchange lists very sharply, and the National Academy itself has adopted such a policy. We have four publications for which this problem should be considered, namely, the *Journal of Geophysical Research*, the *Transactions*, the *Geophysical Mon-*

ograph Series, and *Izvestiya, Geophysics Series*. The exchange policy for each might differ from the others.

A motion was made and passed to keep Tuve's list intact as outlined above for a year. Another motion was adopted that the AGU exchange list be terminated and that a separate list to be called 'the free distribution list' be established for *bona fide* abstract journals. A further motion was made and passed that free distribution of *JGR* to private individuals be held to an absolute minimum but should include non-American officers of the IUGG and its Associations during their incumbency, and that free distribution be made only to key libraries in situations where those concerned would have difficulty in purchasing subscriptions. The General Secretary would have discretionary powers in this.

Report of the President—President Ewing expressed great satisfaction, which may be shared by all, in the progress that has been made in the publications of the Union, calling attention to the display set up for the Annual Meeting. He felt that publication is by far the most important function of the Union and perhaps the only one that we are now really performing as we should. He trusted that there would be continued developments in the future.

Report on elections—Chairman James N. Jordan of the Committee of Tellers presented the report which was printed in the June 1959 issue of the *Transactions* (pp. 140-141). The report was accepted.

Reports of Standing Committees

International Participation—Chairman J. W. Joyce submitted the report of the Committee as set forth in Appendix 1. There was considerable discussion of this report. The following actions were taken by the Executive Committee: (1) The report was accepted. (2) The Chairman of the Committee on International Participation was requested to draw up, in consultation with the Director of the Office of International Relations of the National Academy of Sciences, an appropriate constitution for the U. S. National Committee of the IUGG, based on the Committee proposal published in the August 1958 issue of the *Transactions* (pp. 765-766). (3) This constitution should then be submitted to the National Academy of Sciences for consideration and appropriate action. (4) The Committee on Statutes and By-Laws of the AGU should then prepare suitable additions to, or modifications of, the Statutes and By-Laws to reflect the necessary changes, with the condition that the amended statutes contain a provision that voting on financial matters be restricted to members of the AGU. (5) The proposed Statutes and By-Laws should then be submitted to the Executive Committee for mail ballot and, following Executive Committee action, to the voting membership by mail ballot, as well as to the National Academy of Sciences for final approval.

W. W. Atwood, Jr., Director of the Office of International Relations of the National Academy of Sciences, expressed the opinion that the action taken by the Executive Committee in approving the recommendations of the Committee on International Participation is a noble effort to establish the AGU in a position of leadership in the field of geophysics both nationally and internationally. He foresaw, however, many unsolved problems, and suggested that AGU establish a committee within its own organization for the purpose of effecting international participation perhaps through an enlargement of the Committee on International Participation.

A motion was made and passed authorizing the Committee on International Participation, in cooperation with the officers of the Sections, to begin assembling a list of possible delegates to the Twelfth General Assembly of IUGG to be held in Helsinki in the summer of 1960. The Sections were directed to include the Section President on their lists. The President of AGU will review the lists and make final recommendations to the President of the Academy.

Chairman Joyce recommended that some means be established to assure that only the better spontaneous papers submitted by American authors are presented at the Twelfth General Assembly, pointing out that some of the spontaneous papers presented at the Toronto meeting were reported to have been of poor quality. It was suggested that each Section set up a screening committee for this purpose, and it was noted that in certain Sections, notably Geodesy and Hydrology, such action is now in effect. In the discussion Vice President Berkner stated that it is not just a question of eliminating those papers that do not belong in an international meeting but that we should take constructive steps toward encouragement of desirable symposia in the various Associations and among the Associations, and encourage the submission of papers that represent the forefront of American geophysical science. He recommended positive steps to get our best science to the forefront; namely, the encouragement of symposia, particularly inter-Association symposia, which we feel are pertinent at this time, and finally the screening of spontaneous papers to eliminate those of poor quality. President Ewing expressed the thought that we should not, perhaps cannot, forbid an Association Secretary to accept a paper, but that we might still indicate those as coming officially through the hands of the Committee. It was decided to postpone further consideration of screening committees until the second session of the Executive Committee meeting to be held on May 6.

Joseph Kaplan, President of the International Association of Geomagnetism and Aeronomy, noted that that Association is planning a symposium to be held in Copenhagen a week or so before the Helsinki Assembly, the purpose being to give the program more balance.

J. Frank Schairer, President of the Section of Volcanology, Geochemistry, and Petrology, noted

the difficulty that the geochemists had been undergoing to find a proper place in the International Association of Volcanology, and noted at the same time that geochemistry impinges on meteorology, oceanography, geomagnetism and aeronomy, and hydrology, but did not appropriately fall under any one of them. He felt that further steps must be taken to make the geochemists feel that they have a real home in the IUGG. L. T. Aldrich, Secretary of the Section, noted that the geochemists have found a place in the AGU, but that they desire similar recognition on the international scene. This view is shared rather strongly by National Committees in Canada, Australia, Switzerland, Sweden, and perhaps others. J. Tuzo Wilson, President of IUGG, has recognized this problem and will appreciate a strong expression on the part of our Executive Committee to provide suitable provision for the geochemists.

A resolution was adopted to the effect that the AGU strongly advocates recognition of geochemistry in the IUGG either by the establishment of an International Association of Geochemistry or by making geochemistry a major part in one of the existing Associations, and that this resolution be sent to the President and General Secretary of IUGG and to the Chairmen of the various National Committees that we feel are sympathetic to this idea, at the same time urging the immediate appointment in the IUGG of an Interim Committee to study the problem and bring in firm recommendations in time for action at the meeting in Helsinki in 1960.

Charles A. Whitten, Vice President of the International Association of Geodesy, reported that plans were complete for a Symposium on Distance Measuring Methods by that Association to be held in Washington, May 5-12, 1959. The Section of Geodesy of the AGU is acting as host. About 50 delegates from foreign lands are expected and perhaps 100 or more from the United States. A grant of $4500 for traveling expenses of foreign participants was received from the National Science Foundation, a fund of $2500 was made available to the International Association of Geodesy by the International Council of Scientific Unions, and about $2500 were received from contributors in the United States who prepared exhibits for the meeting. He reported additional meetings of the Association to be held in Trieste, July 5-13, 1959, by the Permanent Commission on Earth Tides; at Venice on July 16-19, 1959, on three-dimensional geodesy; at Paris on September 15-19, 1959, by the International Gravity Commission; and a joint meeting of the Commission on European Leveling with the International Association of Oceanography at Liverpool on October 5-10, 1959, on mean sea level as applied to European leveling.

Ralph N. Wilson, Secretary of the Section of Hydrology, reported that in September 1958 the International Association of Hydrology held a symposium on the Physics of Ice Movement at Chamonix, France, and that a meeting on forest influences in hydrology is to be held at Hannover-Munden, Germany, September 8-13, 1959. The Section has established a committee for screening papers. This worked out very well in connection with the Symposium on the Physics of Ice Movement held in 1958. It is an anonymous committee with full authority to accept or reject papers.

Budget—Consideration of the report of the Committee on Budget was postponed until May 6, 1959.

Statutes and By-Laws—Chairman K. Hilding Beij presented the report of the Committee as set forth in Appendix 2, relating to various categories of supporting members. The report was accepted, and a motion was adopted approving the changes in the Statutes of the Union. The matter will be placed in due course before the membership and the Governing Board of the National Academy of Sciences.

A motion was made and passed approving the recommended changes in the By-Laws of the Pacific Northwest Region (*Trans.*, 36, pp. 375-376, 1955) as follows:

Article 1: Elections—(a) Elections for membership on the Regional Committee shall be held by mail ballot concurrently with National elections of the American Geophysical Union, toward the end of each triennium. Regional ballots will be mailed along with the National ballots. That individual gaining a plurality of votes for a given position will be considered elected.

(b) A Committee of Tellers will count the ballots and make report to the Secretary-Treasurer who shall in turn promptly report the results to the Sections and to those elected.

Article 6: Committees—(c) At least one year prior to each triennial election, the Regional Committee shall appoint a committee on nominations. The chairman of this committee shall activate it immediately, and by proper canvassing and conscientious deliberation this committee shall determine the best possible candidates for membership on the Regional Committee. The nominating committee shall submit its nominations to the Regional Chairman not later than the 15th of October prior to each election year. The Regional Chairman will forward the list of nominees to the National Executive Secretary for preparation of ballots.

Meetings—Chairman P. H. Abelson reported that over 75 will be present at the subscription dinner to be held on May 5 in honor of Walter M. Elsasser, the Twenty-First Recipient of the William Bowie Medal.

He discussed briefly the ever-open question of where our annual meeting should be held—in Washington or elsewhere, at a hotel, or as now planned for this meeting. He noted that the arrangements for meeting in a Washington hotel in the spring of the year are extremely difficult.

There was discussion of the fact that the Sections meeting in scattered auditoria make it diffi-

cult for a person to keep up with more than one Section. It was recommended that there be more joint sessions, and that the Secretaries or Program Chairmen might appropriately choose from among the papers submitted a group of ten general and important ones which they feel represent the advances in the respective fields and have these presented at a general session. With regard to the present scattered meeting, it was felt that with the completion of the new wing of the National Academy of Sciences Building and with the completion of the new State Department Building nearby we are likely to have soon a substantial number of meeting rooms in close proximity that may well mitigate the present scattering in large measure.

Chairman Abelson further noted that the American Physical Society plans next year to meet simultaneously with the National Academy and recommended that our meeting dates be moved to the Thursday, Friday, and Saturday following the National Academy meetings.

With regard to meetings other than in Washington, he saw no objection provided the groups sponsoring them are willing to work hard to make such meetings successful.

A straw vote showed the Executive Committee favoring two half-day sessions devoted to general papers, and Chairman Abelson suggested that it would perhaps be best to have the papers of a more general nature on the first half-day and those relating to a particular subject (a symposium, for example) on the second half-day.

In the absence of William C. Krumbein, one of AGU's representatives on the Council of the AAAS, the Executive Secretary reported that attempts are being made to arrange a symposium on some broad phase of geophysics in connection with the meeting of the AAAS in Chicago between Christmas and the New Year.

Plans for a Conference on Physics of Precipitation being arranged by the Cloud Physics Committee of the Section of Meteorology under the chairmanship of Helmut Weickmann at Woods Hole, June 3-5, 1959, are now about complete. The National Science Foundation has made a grant of $25,000 for this meeting, including funds for the travel of a limited number of foreign participants. It is anticipated that about 70 or 75 will take part. The host organization is the Woods Hole Oceanographic Institution.

Membership—Chairman Earl G. Droessler reported that the applications of about 825 new members have been received in the last six months, being an average of about five a day. He noted that this was largely the impetus of the new *Journal* and the fact that promotional literature was mailed out to the membership of various other groups in December and January. It is further planned to circulate other appropriate lists. New brochures based on the new publication policy are being planned. The number of student members has increased markedly. This bodes well for the future.

Droessler urged that every member take whatever steps he can to increase the number of our corporation members as well as individual members.

Publication matters—Editor J. A. Peoples, Jr., reported an increased number of papers received within recent weeks. Three hundred sixty manuscript pages had been sent to the printer for the July issue of the *Journal of Geophysical Research*. The August issue will contain the abstracts of the papers presented at the annual meeting and will be at least equivalent in size to the July issue. Peoples expressed appreciation of the excellent cooperation on the part of the Board of Associate Editors and others in reviewing papers promptly.

The solar and magnetic data published in the former *JGR* was discussed. It was concluded that, because of the limited readership of this, it should not be published permanently in the new *JGR* but that it should be made available to those concerned in some other way. As a matter of immediate need, however, and until some other satisfactory arrangement is worked out, these data might appropriately be included in *JGR*.

Editor P. H. Abelson reported that efforts have been made to secure papers in various areas previously not too well represented in AGU's publications, and that five have been secured bearing on the Argus Symposium presented recently before the National Academy of Sciences. Furthermore, he expected that papers recently presented at the Space Symposium at the National Academy and possibly some of those to be presented at the coming Symposium on Distance Measuring Methods might find a place in *JGR*. He urged all members of the Executive Committee and others present to search out good papers and direct them to *JGR*.

A motion was made and adopted extending a vote of thanks to the editors for the good progress they have made on these publication matters.

The Executive Secretary stated that the pattern for the quarterly *Transactions* is yet to be set but that the March issue in some measure does this by the establishment of a President's page, the inclusion of a paper of broad scientific interest by J. Tuzo Wilson, the inclusion of a limited number of reviews, the list of the contents of *Izvestiya, Geophysics Series* (part of a promotional effort), notes and personalia, word on Union, Section, and Committee activities, special announcements, and the *IGY Bulletins*.

Geophysical Monograph Series—Chairman A. H. Shapley reported briefly on plans of the newly organized Monograph Board, noting that its first meeting is scheduled for May 6.

Russian Translation Project—In the absence of Chairman Perry Byerly of the Russian Translation Board, the Executive Secretary reported that Pergamon Press has now completed Nos. 1 through 11 of *Izvestiya, Geophysics Series*, for 1957 and that we have been supplied with a copy of the page proof of No. 12. Arrangements are being worked out to have the complete stock brought to the United

States when the job is complete, and Pergamon Press has been asked to submit financial reports, a statement of subscribers, a statement of other distribution, and an inventory statement in order that the arrangement with Pergamon Press may be terminated.

Good progress is being made on the translation of *Izvestiya, Geophysics Series,* for 1958 under the guidance of Translation Editor W. S. Jardetzky, and it is hoped that by early fall the volume for 1958 will be complete. Arrangements have been made with McGregor and Werner of Washington, D. C., and its affiliate, the Murray Press of Forge Village, Mass., for the composition, offset printing, and distribution of *Izvestiya* for 1958 and the storing and selling from storage of *Izvestiya* for 1957, the actual printing, distribution, and storing to be done at Forge Village.

The National Science Foundation has indicated a desire to have some numbers of *Trudy* of the Geophysical Institute in Moscow translated and published. A project has been set up involving four of these, with a total prospective grant of about $14,000.

Reports of Special Committees

Advertising—In the absence of Chairman N. C. Gerson, the Executive Secretary read the report given as Appendix 3, which was accepted. Vice President Berkner stated that advertising must be very greatly increased during the balance of our contract term with our advertising representative or else we should make arrangements for some other representative. An informal showing of hands favored keeping the page rate (basic rate now $250) as it is now. It was agreed that *JGR* should attract prestige advertising, particularly from oil companies, geophysical research instrument companies, geophysical prospecting companies, book companies, and others. Members of the Executive Committee were urged to make an effort to obtain advertising through their various contacts.

Geophysical and Geological Study of Continents—Chairman George P. Woollard made a summary oral report (see Appendix 4), which was accepted. He reported that he is giving a series of lectures on the Earth sciences at various universities and high schools. It was suggested that this would be a good opportunity to distribute AGU brochures.

Cosmic-Terrestrial Relationships—Chairman E. H. Vestine made a summary oral report (Appendix 5), which was accepted. A full scientific report is to appear in the August 1959 issue of *JGR* (see pp. 1077–1091. He noted further that as Chairman of the Committee he planned to write to the National Science Foundation endorsing the technical features of an International Seminar on Solar-Weather Relationships being sponsored jointly by the University of Colorado, the University of California, and his Committee on behalf of AGU at Santa Barbara, California. A motion was made and adopted giving the Committee Chairman this authority.

Geophysical Abstracts—Chairman John Lyman presented the report of the Committee as set forth in Appendix 6. A motion was made and approved to accept the report, expressing the enthusiasm of the Executive Committee for the proposal of the American Meteorological Society to enlarge its *Meteorological Abstracts* and to revise the name to *Meteorological and Geophysical Abstracts* or something similar.

Adoption of the Metric System in the United States—Chairman Floyd W. Hough presented the report set forth in Appendix 7, which was accepted. (Data cited in the report have been brought up to July 1.) A motion was made and adopted that the resolution presented in the report be submitted to the meeting of the Union as a whole on May 6, 1959.

Relations of AGU with U. S. National Committee of IGY—In the absence of Chairman N. C. Gerson, the Executive Secretary presented the report of the Committee as given in Appendix 8, which was accepted.

Macelwane Memorial—No formal committee has ever been appointed, but Earl G. Droessler has been studying this matter in cooperation with President Ewing. He is continuing to explore the possibilities of establishing some suitable memorial.

Recess—The Executive Committee recessed at 18h 10m to resume its meeting immediately following the Business Meeting on May 6, 1959.

Second Session, May 6, 1959

The second session was called to order at 16h 40m by President Ewing in the Board Room of the National Academy of Sciences—National Research Council Building, 2101 Constitution Ave., N.W., Washington, D. C.

Present—P. H. Abelson, Leroy R. Alldredge, L. V. Berkner, J. J. Capello, C. T. Elvey, Maurice Ewing, N. C. Gerson, Floyd W. Hough, B. F. Howell, Jr., W. C. Jacobs, H. R. Joesting, James N. Jordan, W. D. Lambert, H. E. Landsberg, Walter H. Munk, J. H. Nelson, J. W. Peoples, Jr., D. W. Pritchard, John C. Reed, A. N. Sayre, J. Frank Schairer, A. H. Shapley, Waldo E. Smith, and Victor Vacquier.

Budget—Chairman John C. Reed submitted the report of the Committee as given in Appendix 9. The report was accepted and the budget was adopted.

International Participation—In the absence of Chairman J. W. Joyce, the attention of newly elected officers of the Sections was called to the suggestion that, in order to assure technical excellence of American communications at the Twelfth General Assembly of the IUGG in Helsinki, the

President of each Section should appoint a screening committee and that authority be given to the Committee and to the AGU office to make appropriate arrangements with the Secretaries of the various Associations in order that the voluntary papers that they receive are appropriately screened by the U. S. National Committee before they are placed on the program. It was noted that the Section of Hydrology and the Section of Volcanology, Geochemistry, and Petrology have taken such steps and that for some time the Association of Geodesy has been cooperating with such national screening committees. President Ewing noted J. Tuzo Wilson had expressed the opinion that he is not sure that such action is wise, pointing out that small countries may have no topnotch paper but nonetheless the small country has its right to be heard, and that certain other papers not of tip-top quality might accordingly be appropriate. He felt that we should be careful to permit freedom of expression. It was noted that in Hydrology, screening committees are in effect not only in the United States but in England, Belgium, and Holland, as well, and that the initiation of this came from the Dutch and the British. At the same time it was noted that a country is not compelled to set up a screening committee and that this is optional. With such a deluge of papers there needs to be some discrimination from such a country as the United States.

Vice President Berkner again repeated his thought that our effort should be made to secure the good papers and that to a certain extent the problem of secondary papers will take care of itself. On the other hand, we must be careful to avoid having papers presented that are not only poor science but commercial in their character. Thus it was agreed that, first, we should endeavor to get the best papers on the program and the people who represent this work and, further, that the committee might appropriately be called a selection committee rather than a screening committee, noting at the same time that if the National Committees do not exercise some responsibility the Secretary of an Association is hardly in a position to reject a paper.

President Elect Berkner proposed to the incoming officers that, first of all, we consider how to handle the Helsinki Assembly with respect to papers, delegations, and so on, and that then there should be a meeting of the officers to make a determined effort the day before the Executive Committee meeting in the fall to lay out plans for the Helsinki meeting. He urged that Sections cooperate in organizing this special meeting so that a substantial plan may be brought to the Executive Committee. He felt that the plan for the selection of papers is good but that the matter should be left to a considerable extent in the hands of the Section officers to work out (in the case of Seismology and Physics of the Earth's Interior, this involves the Section officers of Seismology and Tectonophysics).

A motion was made and adopted to have the Executive Secretary send any papers, titles, or abstracts that come to him for the Helsinki Assembly to the appropriate Section Secretary for further action and, further, that the Chairman of the Committee on International Participation and the Executive Secretary be free to write to the Secretaries of the International Associations stating that we would like to have knowledge of any American papers submitted to them direct.

Other matters—The Executive Secretary took the opportunity to express appreciation to the retiring officers for the whole-hearted cooperation that the office has had from them on AGU matters. This applies equally to Committee Chairmen.

The Executive Secretary made the further request that the minutes of the Annual Meeting of the Sections be turned in by May 8, if possible, and at the very latest by May 11.

A motion was made and passed expressing, on behalf of the Executive Committee, the appreciation of the efforts of the Executive Secretary during the past three years and also expressing gratitude to President Ewing for the splendid work that he has done as President of AGU. The President in turn thanked the members of the Executive Committee for their whole-hearted support of his efforts.

Adjournment—The meeting adjourned at 17h 02m.

A. Nelson Sayre, *General Secretary*
Waldo E. Smith, *Executive Secretary*

Appendix 1—Report of the Committee on International Participation for the Period July 1956–May 1959

J. W. Joyce, *Chairman*

Leason H. Adams	Perry Byerly	F. W. Reichelderfer
Lloyd V. Berkner	Maurice Ewing, *ex officio*	A. Nelson Sayre, *ex officio*
Walter H. Bucher		Waldo E. Smith, *ex officio*

Following the meeting of the Executive Committee in the fall of 1958, L. Thomas Aldrich and Benjamin F. Howell, Jr., were appointed as consultants to the Committee. The Director of the Office of International Relations, NAS-NRC, or his representative, is always invited to attend meetings of the Committee.

During the past three years, the Committee has

been concerned with matters which group under the following principal headings: (1) the effectiveness of the AGU organization as the U. S. National Committee of the IUGG; (2) the preparation of American positions concerning IUGG activities; (3) the preparation of national reports to the IUGG General Assemblies; (4) the selection and processing of American delegations to IUGG General Assemblies and other meetings; and (5) special symposia organized by the IUGG and its Associations, particularly when such meetings occur in the United States.

(1) *The AGU as the U. S. National Committee of the IUGG*—Following a series of deliberations, the Committee drew up a proposal for the reconstitution of the present Executive Committee, to be renamed "The Council of the American Geophysical Union." The purpose of this change is to meet the criterion for the U. S. National Committee of the IUGG that all United States interests in geodesy and geophysics are adequately represented in the Council so that this body may, in effect, serve as the U. S. National Committee of the IUGG.

Briefly, the proposed Council includes the following with minor modifications in the first paragraph, taken from the August 1958 issue of the *Transactions* (pp. 765-766):

> "(a) *Voting members*—(1) the elected officers of the AGU plus the Executive Secretary (four persons); (2) one member nominated by each Section (this could be the Section President or any other representative depending on the preference of the individual Section) (eight persons); (3) one member nominated by name by each of the four government agencies whose objectives directly involve the geophysical sciences: Defense, Commerce, Interior, and the National Science Foundation (four persons); (4) four members-at-large nominated by the Section of Geophysics of the National Academy of Sciences (four persons); (5) United States officers of the IUGG or its Associations (variable number).
>
> "(b) *Ex-officio (non-voting) members*—(1) the Chairmen of the four related Divisions of the National Research Council (Biology and Agriculture, Physical Sciences, Chemistry and Chemical Technology, and Earth Sciences) and the Chairman of the Section of Geophysics of the National Academy of Sciences (five persons); (2) the Director of the Office of International Relations, NAS-NRC (one person); (3) representatives from two government agencies having non-substantive interests in geophysics, Office of the Science Adviser, Department of State, and the President's Scientific Advisory Committee (two persons); (4) the Chairmen of the various Standing Committees of the AGU (seven persons).
>
> "The names of all of the above persons would be placed in nomination to the NAS and their appointment would be made by the President of the Academy, as is now the case for the U. S. National Committee for URSI.
>
> "An Executive Committee would be selected from the Council to consist of the three elected officers of the AGU and five members of the Council designated by the National Academy of Sciences from among the voting members of the Council. This Executive Committee would handle all but major policy decisions and could be brought together quickly and relatively inexpensively at times between the annual or semiannual meetings of the Council."

This proposal was presented to the Executive Committee as an informational discussion item on May 4, 1958. An invitation for comments has produced only limited discussion.

The Committee now proposes that the plan be put to a vote in the Executive Committee, and, if accepted, that it be sent to the National Academy of Sciences for approval. If approved, it should then go to the total voting membership of the AGU for its consideration and action.

The Committee has recognized that an alternate plan to the above might be the nomination by the AGU of a separate U. S. National Committee of the IUGG. This was not considered as desirable as the proposed plan since it might tend to divorce the international representation function from the domestic functions of the Union and could eventually result in the U. S. National Committee functions being separated from the AGU in the sense that the Committee would not report to the Union.

(2) *The Preparation of American Positions Concerning IUGG Activities*—The Chairman of the Committee on International Participation has attended most of the meetings of the IUGG Bureau, Executive Committee, Council, and Finance Committee since April 1956.

At a combined meeting of the Executive Committee, Council, and the Finance Committee of the IUGG held in Paris in April 1956, a special group of advisors known as the Interim Policy Committee was appointed to act until the XIth General Assembly at Toronto in September 1957. The Chairman of the Committee on International Participation was a member of this Interim Policy Committee.

At the XIth General Assembly of the IUGG in Toronto, the Bureau of the Union was increased to seven persons including three members selected-at-large. The Chairman of the Committee on International Participation is one of the members-at-large. As such, he has attended special meetings of the Bureau held immediately following the Toronto General Assembly, again in Paris in December 1957, and finally in Moscow in July 1958. Appropriate reports of these meetings have been submitted to the Executive Committee and are a matter of record.

(3) *The Preparation of National Reports to the IUGG General Assemblies*—The IUGG requests national reports covering the three-year interval immediately preceding a General Assembly. To as-

sure the preparation of a comprehensive U. S. National Report of high standard for the XIIth General Assembly of the IUGG to be held in Helsinki in 1960, Leason H. Adams has been asked and has agreed to take the responsibility of compiling and preparing for publication such a report.

(4) *The Selection and Processing of American Delegations to IUGG General Assemblies and Other Meetings*—At a meeting of the Committee on January 23, 1959, the following suggestions were made concerning the selection and processing of the American delegation to the XIIth General Assembly at Helsinki, July 25-August 6, 1960:

(a) An announcement of the general problem concerning the selection and briefing of the delegation at the Helsinki General Assembly to be made to the members of the Executive Committee at its final meeting following the 40th Annual Meeting of the AGU in May 1959. The incoming officers, in particular, will be concerned with this.

(b) The initiation of immediate steps necessary to select the official delegation for Helsinki. Several proposals have been made. One is for the Committee on International Participation to prepare a list of proposed delegates, with the assistance of the Sections, to be submitted to the President of the AGU for approval and transmission to the NAS. The Academy would then confirm the list, making such additions or changes as it deemed desirable, and would then proceed with the necessary notification to the selected delegates with February 1, 1960, as a target date for all such notifications.

(c) The organization of a suitable briefing session is planned during the 41st Annual Meeting of the AGU in the spring of 1960 in order to consolidate the delegation and to establish an effective working schedule for the Helsinki General Assembly.

(5) *IUGG Symposia*—The Committee has been kept informed of plans being developed by Charles Whitten on behalf of the International Association of Geodesy of the AGU for a symposium on the use and development of electronic distance measuring equipment which will be held May 5-12, 1959.

(6) *Miscellaneous*—(a) *Reviews of Manuscripts for the General Assembly at Helsinki*—It is proposed that voluntary scientific contributions to the IUGG General Assembly be reviewed by appropriate committees within the AGU to assure a high level of scientific content. If the Executive Committee approves, a call should be issued immediately for appropriate titles and manuscripts for the Helsinki General Assembly so that adequate time will be available for appropriate review. Such papers would then be submitted to the IUGG as American contributions by the AGU as the U. S. National Committee. The Executive Secretary of the AGU would make appropriate arrangements to assure review of any communications which are not initially submitted by authors to the AGU.

(b) *Geochemistry in the IUGG*—As a preliminary step toward the preparation of an answer to a recent request from the President of the IUGG concerning a place for geochemistry in that organization, a small group has been organized on an *ad hoc* basis to make appropriate recommendations.

Appendix 2—Report of the Committee on Statutes and By-Laws

K. Hilding Beij, *Chairman*

Walter B. Langbein C. A. Whitten

1. By letter of October 21, 1958, from Vail P. Schermerhorn, Secretary-Treasurer of the Pacific Northwest Region, request is made for approval of changes in the By-Laws of the Regional Branch. The proposed changes, as given in the letter, concern only changes in election dates for the Region to make them correspond with those of the Union. The Committee on Statutes and By-Laws recommends approval.

2. The following addition to the Statutes of the Union is recommended for adoption: To Article 3, Membership, add

(g) *Supporting Members*—Corporations, other organizations, and individuals interested in geophysics and desirous of supporting the Union may become members under the following classifications upon election by the Executive Committee of the Union and payment of the annual sums indicated: Contributing Members, $500; Sustaining Members, $1000; Benefactors, $5000. Individual Supporting Members and the designated representatives of corporation or other organization Supporting Members shall enjoy the privileges of Members.

Appendix 3—Report of Committee on Advertising

N. C. Gerson, *Chairman*

Samuel C. Coroniti Karl Dyk J. Lamar Worzel

Waldo E. Smith and N. C. Gerson visited Howland and Howland on April 21, 1959, and spoke to Messrs. Howland and Ladd relative to increased advertising in the *J.G.R.* The present display book utilized by Howland and Howland was examined, and specific suggestions were given for improving

the approach in obtaining advertising. New data sheets are being prepared for them.

It was generally agreed that a more forthright approach to prospective customers will be used and that emphasis will be placed upon the more vigorous areas of geophysics, specifically space technology, space explorations, communications, oceanographic research, and allied fields. It was also pointed out that the *Journal of Geophysical Research*, far from being a new Journal, is now in its 64th year, and that it enjoys an extremely high degree of prestige in the field. Under these circumstances, it was felt that prospective advertisers can be urged to take advantage of the high quality and past reputation of the *JGR* by placing advertisements in the *Journal*.

The Chairman was unhappy over the fact that the card listing of prospective advertisers had been drastically culled by Howland and Howland. In place of over 600 cards which had originally been furnished them, there now were about 150 to 200, and these did not seem to be actively pursued. Attempts were made to obtain copies of Howland and Howland's letters written as follow-up to Dr. Berkner's letters.

The Chairman feels that it would have been highly desirable to have arranged for the next 18 months a controlled advertising test. The advertising obtained for the *JGR* by the advertising representative, Howland and Howland, could be compared with that obtained on a strictly commission basis for the *Transactions*. In the latter case, the agent would be designated by the American Geophysical Union. In any event the Chairman plans to contact certain of the AGU membership for assistance in writing to specific industrial concerns for advertising.

Appendix 4—Report of the Special Committee on the Geophysical and Geological Study of Continents, 1957–1959

G. P. Woollard, *Chairman*

Francis Birch
W. E. Bonini
Ross Gunn
Sigmund Hammer
J. C. Harrison
J. B. Hersey
B. F. Howell
P. M. Hurley
M. J. S. Innes
H. R. Joesting
Gordon Lill
L. L. Nettleton
Charles B. Officer
James Peoples
Frank Press
Donald Rice
Howard Tatel
J. Tuzo Wilson
J. Lamar Worzel

During the past year arrangements were completed with the U. S. Geological Survey to print a regional Bouguer Gravity anomaly map of the United States with a 10 mgal contour interval on a scale of 1:2,500,000. This is the same scale as the geologic map prepared by the U. S. Geological Survey and the tectonic map prepared under the auspices of the American Association of Petroleum Geologists. The gravity map will be available both separately and as an over-print on the geologic and tectonic maps. This map will culminate a program started in 1940 under the auspices of the Committee and on which the Chairman has had the very material assistance of not only individual members of the Committee but also that of the U. S. Coast and Geodetic Survey; the U. S. Geological Survey, Geophysics Branch; many oil companies and geophysical prospecting companies; state geological surveys; and individuals at various universities. Financial assistance in carrying out a field program for obtaining data in unmapped areas was obtained from the Geological Society of America, the National Science Foundation, and the Air Force Cambridge Research Center. As much of the data obtained is on a floating datum and varying calibration standards were used, it has been necessary to adjust all the data. This is being done at the University of Wisconsin. Principal facts are punched on IBM cards and free-air and Bouguer anomalies for six values of density covering the normal range of geologic materials are computed on an IBM 650. The material, when in final form, will be deposited with the U. S. Coast and Geodetic Survey, where it will be available for general use. To safeguard the scientific investment of university personnel, in particular, who have contributed material, arrangements have been made with the Geological Society of America, who supported much of the field work for the program in its initial stage, to publish a special memoir dealing with the relationship of gravity to geology. The publication of this memoir will be timed to coincide with that of the map.

In cooperation with the American Association of Petroleum Geologists, the Committee, through its Chairman, is working on a basement surface map of the United States on a scale of 1:2,500,000. Although a similar map was prepared under the auspices of this Committee in 1939, subsequent drilling and geophysical work has largely outmoded the 1939 edition. The Chairman of the Committee has accepted the responsibility of preparing that portion covering the North Central States and also for getting together all geophysical data bearing on the basement for the entire country. Although the assistance of the various universities, the state geological surveys, the Geophysics Branch of the U. S. Geological Survey, the Gulf Oil Corp., and the Gravity Meter Exploration Co. on this study cannot be over-emphasized, there is

need for more material and anyone knowing of data that might be made available is strongly urged to contact the Chairman.

During the past year, a report on the regional distribution of earthquakes throughout the United States and their relation to geology was published [*Woollard*, 1958]. The project was started under the auspices of the Committee in 1936 and carried on as a continuing study through the cooperation of the U. S. Coast and Geodetic Survey.

Another cooperative program is that with the Society of Exploration Geophysicists in preparing a gravity anomaly map of North America on a scale of 1:5,000,000. This is the scale of the Geologic Map of North America prepared by the Geological Society of America, but as yet no provision has been made for the printing of the gravity map.

Another phase of the Committee's activity has been the implementing of geophysical programs at various universities where there are graduate students interested in Earth science, but limited facilities. By arranging for the loan of equipment, IBM processing of data and setting up of cooperative programs, research in geology and geophysics was advanced at Wesleyan College, the University of North Carolina, Virginia Polytechnic Institute, the University of Tennessee, the University of Mexico, and Brisbane University. On a similar basis, the loan of gravimeters was arranged so that gravity observations were possible on the British Trans-Antarctic traverse across Antarctica, and on Ice Station A in the Arctic Ocean during the International Geophysical Year. The United States program in gravity in Antarctica was similarly expedited through the loan of equipment by the Phelps-Dodge Copper Co., the Gravity Meter Exploration Co., and the Romberg-LaCoste Co., when the original equipment turned out to be unsatisfactory for Antarctic traverse measurements and long-period ties to the Antarctic bases.

Inasmuch as several members of the Committee are directly engaged in the study of the Earth's crust through gravity and seismic measurements, this subject was the topic of discussion at the annual meeting of the Committee in Washington on May 4, 1959. It was the concensus of the Committee that an effort be made to mount as large a cooperative effort as possible on all seismic blast studies. Although crustal travel-time data can be built on a piece-meal basis from numerous explosive shots using limited recording facilities, the significance of the investigation would be immeasurably improved if simultaneous recordings could be obtained at all ranges from a single explosive blast. This, and magnetic tape recordings which could be played back for analytical studies, were regarded as the two most significant improvements that could be made at this time.

In view of the large number of radioactive age determinations that are now being made, it was felt that a map summarizing all information available for the various geologic provinces would be of considerable general interest and geologic value. Such a map has already been started by Patrick M. Hurley and it is hoped it can be published within the year.

Another map that might be prepared at this time is that of variations in crustal structure for the United States based on the Bouguer anomaly map. A study relating gravity and seismic quantities concerning crustal structure has already been completed by the Chairman and the results suggest that a first approximation of crustal structure can be reliably deduced from the regional Bouguer gravity anomalies.

As the Committee has no budget, programs such as those described above, are in large measure dictated by the interests of its members. However, the stature and recognition of the Committee has been invaluable in securing the cooperation and assistance of university, government and industrial organizations in advancing various projects related to the geological and geophysical study of the continents.

Reference

Woollard, G. P., Areas of tectonic activity in the United States as indicated by earthquake epicenters, *Trans. Amer. Geophys. Union*, 39, 1135–1150, 1958.

Appendix 5—Report of the Committee on Cosmic-Terrestrial Relationships, 1958–1959

E. H. Vestine, *Chairman*
Walter Orr Roberts, *Vice Chairman*

R. N. Bracewell
J. W. Chamberlain
C. T. Elvey
J. W. Evans
H. Friedman
S. Fritz
H. K. Kallmann
S. A. Korff
R. R. McMath
M. G. Morgan
H. Odishaw
C. E. Palmer
A. H. Shapley
S. F. Singer
T. L. Skillman
J. A. Smagorinsky
A. H. Waynick
F. L. Whipple
H. C. Willett

During the past year notable progress has been achieved in the description and understanding of our cosmic-terrestrial environment. The Committee has noted with great satisfaction many new scientific findings in its area of interest during the International Geophysical Year, now terminated,

and during the continuing International Geophysical Cooperation now under way; these activities have been reported on elsewhere, and no attempt will be made to cover them here. In addition to these activities many other scientific ventures in cosmic-terrestrial relationships continue to excite our admiration and regard, such as the continuing programs of rocket, satellite, and space-probe research. These have provided direct measurements of the radiations from space, both wave and corpuscular, and in particular the more accessible Van Allen radiation belt reported upon during the Symposium organized by this Committee held at the Union's meeting in 1958.

A Symposium including papers on Solar and Other Cosmic Influences on Planetary Weather and Ionospheres, and Influences of Variable Solar and Other Cosmic Phenomena on Terrestrial Weather was held during the annual meeting on May 4, 1959; nearly 200 Union members and guests attended. With W. O. Roberts as Convenor and Chairman, Seymour Hess of Florida State University gave the leading address, the first paper cited above. He discussed the origin of the blue haze of Mars and offered a speculative suggestion for the sudden planet-wide clearing under solar-flare effects or other solar influences. He and other participants also discussed Jupiter's atmosphere and ionosphere.

The second half of the Symposium was devoted to the second title above, the leading address on which was presented by C. Palmer of the University of California, Los Angeles. He said that the statistical evidence to date suggests that the time has come to attempt physical explanation of the apparent correlations. Attacking the problem piecemeal, he stated, we could profitably begin by explaining the very large changes in temperature and pressure associated with the breakdown of the polar cyclone in the stratosphere, which breakdown appears to be connected with solar activity.

The Committee in reviewing the progress of the past year has noted one area of its interest in which it has some grave concern respecting requirements by the American Geophysical Union. This is in the general area of solar-terrestrial relationships. It is of the utmost importance that systematic solar observations, by improved techniques, be continued and extended in this area.

The Committee notes with alarm that systematic solar observations have been curtailed at several centers, and expresses the wish that all efforts be made that physically significant solar parameters be measured day-by-day on a regular basis, and that data from these measurements be promptly disseminated to the many users of such information.

Appendix 6—Report of Committee on Geophysical Abstracting

JOHN LYMAN, *Chairman*
WERNER A. BAUM JOHN C. REED
J. W. JOYCE ARTHUR H. WAYNICK

The previous report of this Committee, submitted to the Executive Committee meeting of October 18, 1958, was published in the *Transactions* for December 1958 (p. 1197). Since then, some significant developments have taken place in the field of interest of the Committee.

As forecast, the *International Journal of Geological Abstracts* has not yet been commenced. *Geological Abstracts* has been discontinued, and *Geo-Science Abstracts* was begun by the American Geological Institute in January 1959. The latter is primarily a compilation of authors' abstracts of North American literature and embraces geology and solid-earth geophysics.

We have continued to work closely with the American Meteorological Society on the possibility of enlarging the scope of *Meteorological Abstracts and Bibliography*. On March 14 the President of the American Meteorological Society wrote to the President of AGU informing him that at its January 26-28 meeting the Council of the AMS had voted to seek support of the National Science Foundation to enlarge *Meteorological Abstracts and Bibliography* in order to achieve more comprehensive coverage of oceanography, hydrology, seismology, and geomagnetism. It is understood that the proposal of the AMS to this end has reached the National Science Foundation in early May. It should be added that both the AMS Council and its President expressed appreciation to the AGU for its suggestion that the AMS extend its abstracting coverage in the field of geophysics.

It is accordingly recommended that if the views of the AGU are sought by the NSF, we strongly endorse this proposal, and offer to provide any technical guidance in our specialties that may be required.

It is again recommended that a permanent committee of the Union be established to work on the implementation of world-wide coverage of geophysical abstracting in all its phases.

At the Executive Committee meeting in May 1958 (*Transactions*, August 1958, p. 758), a motion was adopted that AGU adhere to the new National Federation of Scientific Abstracting and Indexing Services. This action has not yet been implemented, and it appears now that AGU may not be eligible for membership, since a requirement is the issuance of an abstracting or indexing periodical at least twice yearly. The Federation held a second meeting in February in Washington. As of May 1, 1959, it is opening for business with a Washington office under Raymond Jensen, formerly of the Office of Technical Services.

Appendix 7—Progress Report of the Committee for the Study of the Metric System in the United States

FLOYD W. HOUGH, *Chairman*

CARL I. ASLAKSON
FINN E. BRONNER
JOHN G. FERRIS
HELMUT E. LANDSBERG
G. MEDINA
JOHN A. O'KEEFE
MILTON O. SCHMIDT
LANSING G. SIMMONS
GEORGE D. WHITMORE
(JULIUS C. SPEERT
and THOMAS DANDO as
alternates)

L. V. JUDSON, *Consultant*

At the May 7, 1958 business session of the American Geophysical Union, the Bronner resolution was passed unanimously requesting President Ewing to appoint a Special Committee of the AGU for the Study of the Metric System in the United States. The resolution, printed in the *Transactions* of June 1958 (p. 558), directed the Committee to report at the May 1959 meeting. Accordingly, the President appointed the Special Committee noted above.

The Committee held its first meeting on October 29, 1958 and has held four subsequent plenary sessions interspersed with a number of partial meetings of working groups. Correspondence was opened with A. H. Hughes of London, Deputy Chairman of the Metric Committee of the British Association for the Advancement of Science. The British Committee has parallel instructions to those of our Committee with the added feature of considering the conversion of their present monetary system to a decimal system. Our Committee entertained Hughes at a luncheon during his visit here on December 28. This was followed by an interesting session at which the similar problems of the two countries were discussed. Several members of the Committee attended the Metric System discussion at the December meeting of the American Association for the Advancement of Science.

The various members of the Committee have made independent studies on the adoption of the metric system in the United States and submitted reports on such phases as: the effect on industry, the effect on foreign trade, the effect on Government (including state and municipal), the advantages and disadvantages of the metric system, the history of the metric system in the United States and its use in foreign countries, the introduction of the metric system into the schools, publicity programs, best means of making the transition, and proper approach to Congress.

It was early recognized by the Committee that an initial poll must be taken to ascertain the feeling of the scientific field on the question of a change to the metric system. Accordingly, a subcommittee was appointed to draw up a suitable questionnaire and a Letter to the Editor of *Transactions* (see *Trans.*, pp. 38–39, March 1959); this plan was later extended to include the editors of a number of scientific and engineering journals. An excellent response was made to the Committee's request for printing the letter and questionnaire with the result that they have been carried already in the official publications of the following organizations: American Society of Civil Engineers, American Society of Mechanical Engineers, Institute of Radio Engineers, American Association for the Advancement of Science, Society of American Military Engineers, American Geophysical Union, and American Society of Photogrammetry.

Two in addition to the above will carry the letter and questionnaire in their next issues. It is felt that these organizations with perhaps 175,000 readers, excluding overlapping membership, should furnish an adequate coverage of the scientific and engineering fields. The replies to these questionnaires are coming in daily and will no doubt continue for some time owing to the recentness of some of the publication issues. To date, we have had about 700 returned. While this number is a small percentage of the readers of the above publications, it should be noted that in all cases the questionnaire was printed in such a manner that it was necessary to cut it out of the magazine, often destroying text material on the opposite side of the sheet. Add to this the necessity to address and stamp an envelope, and we must conclude that the 700 represent only the most enthusiastic of those concerned with the subject. A considerable number of one- and two-page letters have been received with excellent suggestions and encouragement. Furthermore, of the 700 questionnaires received, about 14% have indicated willingness to aid financially.

The tabular analysis of the first 577 questionnaires returned, for the computation of which the Committee is indebted to personnel of the U. S. Coast and Geodetic Survey, is shown in Table 1. The tabular analysis is self-explanatory, the nine questions being shown by number at the heads of the columns and the various professions by number at the left.

The full Committee agreed that it would advocate strongly a transition period of not less than one human generation, or 33 years, between the passage of a bill by the Congress and the effective date when the metric system would become the 'only official system' of weights and measures in the United States. It is felt the smooth transition afforded by this 33-year period will remove much of the opposition which has defeated all previous bills on the adoption of the metric system. It will provide ample time for the schools to adjust to the metric system, for almost all equipment in

TABLE 1—*Analysis of Questionnaire*

		Present usage (Ques. 2)				Change advantageous (Ques. 3)			Period for change (Ques. 4)		Use Centigrade temperature (Ques. 5)			Export trade now suffering (Ques. 6)			Metric system adaption inevitable (Ques. 7)			Cost of gradual change prohibitive (Ques. 8)			Sponsorship (Ques. 9)				
Profession*	No. answering	Metric	British	Other	Answering	Yes	No	Answering	Average	Answering	Yes	No	Answering	Yes	No	Answering	Yes	No	Answering	Yes	No	Answering	Prof. Soc.	Industry	Education	Government	Answering
		%	%	%	%	%	%	%	years	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0	79	46	52	2	97	91	9	99	22	97	89	11	100	70	30	59	63	37	99	13	87	96	30	19	16	35	97
1	50	60	39	1	98	94	6	98	21	100	92	8	100	68	32	44	63	37	92	9	91	90	48	18	08	25	92
2	123	74	24	2	99	96	4	99	21	96	98	2	98	56	44	39	71	29	97	3	97	97	39	08	09	43	98
3	3	12	73	15	100	67	33	100	20	100	100	0	100	50	50	67	33	67	100	0	100	100	44	44	11	00	100
4	101	22	76	2	99	93	7	99	21	96	97	3	98	78	22	36	85	15	61	6	94	63	37	15	14	34	99
5	50	37	62	1	98	96	4	100	25	98	98	2	100	77	23	52	62	38	94	8	92	96	42	13	08	37	100
6	35	12	85	3	100	80	20	100	26	100	83	17	100	62	38	60	69	31	100	9	91	97	29	23	09	40	100
7	25	39	61	0	92	92	8	100	18	96	88	12	100	46	54	52	64	36	100	4	96	96	41	15	03	41	100
8	2	35	60	5	100	100	0	100	20	100	100	0	100	100	0	50	100	0	100	0	100	100	17	00	17	67	100
9	14	69	31	0	100	100	0	100	18	93	100	0	100	100	0	50	93	7	100	0	100	93	59	05	16	20	100
10	9	75	23	3	100	100	0	100	20	100	100	0	100	100	0	22	88	13	89	0	100	100	50	11	17	22	100
11	13	48	41	11	100	100	0	100	23	100	100	0	100	100	0	31	73	27	85	0	100	69	40	10	17	33	100
12	2	13	87	0	100	100	0	100	15	100	100	0	100	100	0	50	100	0	100	0	100	100	67	17	00	17	100
13	10	75	25	0	100	100	0	100	26	90	100	0	100	75	25	40	75	25	80	0	100	100	28	03	18	53	100
14	26	37	55	8	100	100	0	100	19	100	100	0	100	63	38	62	67	33	92	4	96	96	32	24	16	28	96
15	3	25	73	2	100	100	0	100	28	100	100	0	100	50	50	67	33	67	100	0	100	100	11	44	11	33	100
16	13	58	42	0	92	92	8	100	16	92	100	0	92	75	25	31	77	23	100	0	100	100	58	16	06	20	100
17	11	39	60	1	100	100	0	100	22	100	100	0	100	100	0	45	60	40	91	20	80	91	46	06	16	33	91
18	8	66	34	0	100	100	0	100	21	100	100	0	100	100	0	50	63	38	100	0	100	100	39	09	14	39	100
	577	47	51	2	98	94	6	99	22	97	95	5	99	69	31	46	70	30	90	6	94	90	39	14	12	35	98

* Key to Professions

0 OTHERS (Including not identified)
1 PHYSICS
2 CHEMISTRY
3 MATHEMATICS
4 CIVIL ENGINEERING
5 ELECTRICAL ENGINEERING
6 MECHANICAL ENGINEERING
7 GEOLOGY
8 AERODYNAMICS
9 MEDICAL
10 PHARMACOLOGY
11 RESEARCH SCIENTIST
12 METALLURGY
13 BIOLOGY
14 PHOTOGRAMMETRY
15 GEOGRAPHY
16 METEOROLOGY
17 TEACHING
18 OCEANOGRAPHY

English units to become obsolete and to be replaced by equipment in metric units during this period, and for trades and professional personnel now using the English system exclusively to be retired and to be replaced by the younger generation thoroughly schooled in the metric system. With the impetus of a bill having passed Congress, the Committee feels that the change-over to the metric system would be rapid in much of the economy and that ten or 15 years would see the transition perhaps as much as 80% complete. The remaining legal period for the English system would avoid economic loss to certain owners of heavy equipment not yet obsolete and would carry the older personnel on to retirement.

As indicated by the above list of organizations whose publications have carried the letter and questionnaire, the attached analysis of the replies represents the opinions almost entirely of scientific and engineering personnel. A much larger poll remains to be taken of industry, labor, agriculture, women's organizations, as well as the legal, medical, teaching, and other professions. It is believed that this can be done largely in the same inexpensive manner as that used in polling the scientists and engineers. There will be certain clerical, postal, and analysis expenditures, however, for which an item has been requested in the 1960 budget. The Committee hopes to raise needed additional funds from those persons who have indicated on the questionnaires that they are willing to assist financially.

Problems to be considered in the near future include the question, extent, and mode of cooperation with the existing Committee of the AAAS, and any similar metric committees in the United States and Great Britain. Close cooperation by all U. S. interested committees is essential to provide proper support for an early bill before the Congress, assuming that the results of the completed study indicate the desirability of such action. The Committee is considering the advisability of espousing a National non-profit corporation consisting of all interested bodies, with representation from all walks of life, in order to conduct a thorough and unbiased study of the entire problem. Such an organization would be in the best position to obtain the necessary financial support and its prestige would be an invaluable asset in the handling of the appropriate bill before the Congress.

In view of the very high affirmative reaction in regard to the metric system, some 94% of the questionnaires already analysed from a large coverage of the scientific and engineering personnel in the United States, the Committee presented the resolution, published on page 141 of the June 1959 issue of the *Transactions*. This places the American Geophysical Union squarely on record as urging an end to the present confusion of two legal systems and the adoption of the metric system as the only official system of weights and measures in the United States, effective 33 years after passage of appropriate action by the Congress.

The Committee recognizes that there are many economic problems in our change-over to the metric system. It does not believe that a five- or even ten-year period such as has been proposed in the past, is adequate for this change; it does feel that a proposal to convert over a 33-year period is entirely practicable. It should be a smooth transition with little attendant hardship or economic loss. It appears that the leading nation of the world can no longer fail to take the necessary steps to rid itself of its self-imposed isolation in the present non-standardization of its weights and measures with respect to most of the nations of the world any more than it can afford political isolation in this modern age of science and technology.

Appendix 8—Report of Committee on Relations of AGU with U. S. National Committee of IGY

N. C. Gerson, *Chairman*

E. R. Piore, *Vice Chairman* William E. Benson, *Secretary*

E. G. Droessler M. A. Tuve J. A. Van Allen
R. R. Revelle J. T. Wilson

The Committee held several meetings since its origination and examined the problems of (a) publication of papers, and (b) relationships with the IGY. With respect to the former the Committee's suggestions that the author's institution defray page charges has been adopted. The Committee's basic concepts for integration of the *Journal of Geophysical Research* into the American Geophysical Union structure were subsequently followed up by a special committee and generally adopted.

The Committee sponsored a Symposium on Satellite Research during the Washington AGU meeting in 1958.

The Committee is still unhappy over the format retained in the program for the annual meetings.

The Committee again suggests that the format be changed to conform with that of the Physical Society, URSI, National Academy of Sciences, and other reputable scientific groups.

The publication of IGY results obtained by the U. S. National Committee for the IGY is proceeding satisfactorily. Thus, for example, officers of the U. S. National Committee for IGY are on the AGU boards for the journal and the Monographs.

Appendix 9—Report of the Committee on Budget, April 30, 1959

JOHN C. REED, *Chairman*

E. H. BRAMHALL L. O. QUAM

One member of the Budget Committee, Dr. Bramhall, has moved from Washington and was not available for the preparation of this report. The remaining members respectfully submit the following brief analysis of the fiscal affairs of the Union in fiscal year 1959 as compared to the budget for that year and a proposed budget for fiscal year 1960 (starting July 1, 1959) for approval or modification. Both the budget analysis for 1959 and the proposed budget for 1960 were prepared with the full assistance of the Executive Secretary.

The Union appears to be comfortably solvent. However, that desirable situation clearly is because of the grants received and expected from the National Science Foundation for the temporary support, over a planned five-year period, of the *Journal of Geophysical Research*. In your Committee's opinion, the Union must bend every effort to become self-supporting, including the *Journal*, by the end of fiscal year 1961.

ANALYSIS OF BUDGET FOR 1959

The Budget Committee made several provisional budgets for 1959 because the rapidly changing situation, relative primarily to the starting of the *Journal of Geophysical Research* and to an application to the National Science Foundation to support the *Journal* until it becomes well established, did not permit the preparation of a firm budget before the start of the fiscal year.

The latest 1959 budget (December 1958 *Transactions*, p. 1193) estimated total receipts of $254,100 and total expenditures of $140,360. Actually it now appears that receipts will be about $190,000 and expenditures about $121,000.

Receipts in 1959—From the above it is seen that receipts were overestimated by about $64,000. The overestimation is largely because the NSF actually provided the Union with $75,000 for starting the *Journal* instead of the $146,000 that was expected at the time the estimate was made. If the Union had received the amount earlier expected in 1959, receipts would have been underestimated by about $7000. In the latest budget for 1959, the Committee underestimated receipts from dues by about $7400. The actual increase in membership represents substantial growth. The Committee overestimated advertising receipts and underestimated royalties.

Expenditures in 1959—Large departures from the estimated expenditures appear in the items pertaining to the *Journal*. Printing, mailing, etc., actually will cost around $17,000 less than estimated. This accounts for most of the underestimation of expenditures although some other budget items were substantially above and others substantially below the estimated amounts.

BUDGET FOR 1960

The following paragraphs pertaining to points to which the Committee wishes to call attention are keyed by the numbers to the proposed budget for 1960:

(1) Attention is called to the fact that the present subscription rate is $16.00. The $20.00 estimate is based on the expressed intention of the Executive Committee.

(2) The Reprints item under Receipts from publications is estimated at only $600 because most such income is expected henceforth to be from page charges rather than from sale of reprints.

(3) The Advertising item under Receipts from Publications was overestimated for the year ending and has been reduced, based on experience, to $8000 in the present budget. Your Committee hopes that actual receipts will be higher.

(4) The NSF grant for the *Journal of Geophysical Research* was expected to be $146,000 for three years when the latest budget for the current year was prepared. Subsequently the NSF granted the AGU $75,000, with the expectation that additional funds might be granted later. It is now anticipated that $40,000 for the *Journal of Geophysical Research* may be received in the next budget year.

(5) Salaries in the main office of the AGU now aggregate about $36,000. A precise figure is not available because some of the salaries are for part-time. All of the items indicated by superscript '5' in the Estimated Expenditures table are largely or entirely for those salaries. The item of $20,500 for salaries under "General office expenditures" includes a salary increase for the Executive Secretary of $500 per year that is recommended by the Budget Committee.

(6) The Budget Committee recommends that a start be made in furnishing and equipping the main office more adequately and has provided $2000 for that purpose.

(7) Includes $250 recommended by the Budget Committee for the requirements of the Special Committee for the Study of the Metric System in the United States.

REGULAR OPERATIONS, 1960

Estimated Receipts		
Membership dues		
5,300 members at $10	$53,000	
300 members (student) at $3	900	
33 corporation members at $100	3,300	$ 57,200
Publications		
Journal of Geophysical Research, subscriptions, 1,050 at $20	21,000[1]	
Transactions, 1000 at $4	4,000	
Reprints	600[2]	
Advertising	8,000[3]	
Page charges, 1000 pages at $15	15,000	48,600
Other		
National Research Council grant	400	
Interest	3,600	
Monographs	9,000	
Royalties (microcards and reprinted *Transactions*)	1,200	
National Science Foundation grant (for *Journal of Geophysical Research*)	40,000[4]	
Miscellaneous (includes contributions to permanent fund)	2,500	56,700
Total		$162,500
Estimated Expenditures		
Journal of Geophysical Research		
Editorial office		
Salary and Social Security	$ 5,200	
Honorarium	4,000	
Stationery, supplies, rent, and communications	2,000	$ 11,200
AGU office		
Preliminary review, proofreading, processing, subscriptions, etc. (largely salaries)[5]	12,000	
Printing 12 issues	60,000	
Reprints	3,600	75,600
Transactions		
Preparation, proofreading, etc. (largely salaries)[5]	1,500	
Printing and mailing	5,400	
Reprints	200	7,100
General office expenses		
Rent	5,100	
Salaries[6]	20,500	
Retirement contribution	1,200	
Stationery and supplies	2,400	
Equipment[8]	2,000	
Postage and communications	3,000	34,200
Meetings		
Regional	300	
Annual	1,500	1,800
Miscellaneous		
Bowie medal	130	
Sections	100	
Committees[7]	450	
Travel	1,000	
President's Fund	100	
Directory	2,600	
Monographs	9,000	13,380
Total		143,280
Excess of receipts over expenditures		$ 19,220

NON-BUDGET ITEMS

Below are shown some fiscal data for projects of the Union financed, or expected, by the NSF, that, because of their specialized nature, are not included as regular budget items.

	Special Projects—Balance as of April 1, 1959 except as noted	
Izvestiya, 1957	$14,944.95	Remainder of grant.
Izvestiya, 1958	41,414.03	Remainder of grant of $44,835.
Izvestiya, 1959	45,000.00	Expected to be received in 1959.
Cloud Physics Conference	24,582.95	Conference to be held in June 1959. Remainder of grant of $25,000. Results to be published as Monograph 5.
Geodesy Conference	6,007.25	Conference held in December 1958. Remainder of grant of $6,800. Results to be published as Monograph 4.
Trudy	14,000.00	Application has been made for translation and publication of four numbers.

The Union is publishing Monograph 3 on a repay basis from the National Academy of Sciences, which has NSF funds for the purpose.

Union, Section, and Committee Activities

Meetings of the Geophysical Society of Hawaii

The Geophysical Society of Hawaii, serving also as AGU's regional group in the Mid-Pacific, has continued to hold occasional meetings. In the late winter John W. Mulford presented a motion picture on the 1958 eruption of Capelinhos Volcano, Fayal Island, Azores; in April, Max A. Kohler spoke on Recent Studies of Evaporation and Evapotranspiration; in May, K. J. Murata, J. S. Naughton, J. P. Eaton, and G. A. Macdonald presented a series bearing on volcanological activity; and more recently, Frank N. Visher and John F. Mink presented a summary of ground-water studies of southern Oahu.

Woods Hole Conference on Cloud Physics

A second Woods Hole Conference on Cloud Physics was held on the theme "Physics of Precipitation," June 3-5, 1959, under the sponsorship of AGU's Committee on Cloud Physics, Helmut Weickmann, Chairman, with the aid of a grant from the National Science Foundation. The Woods Hole Oceanographic Institution acted as host, the sessions being held at the Institution and at the nearby Whitney Estate which is on lease to the National Academy of Sciences. Some 45 papers were presented at sessions bearing the themes: "Morphology of Precipitation Clouds and Cloud Systems," "Morphology of Precipitation and Precipitation Particles," "Fundamental Precipitation Processes," "Hail Formation," and "Artificial Precipitation Control." About 80 were in attendance, with representatives from Australia, Japan, Sweden, Switzerland, France, Germany, England, and Canada. It is planned that the papers and discussions of the Conference will be published as Geophysical Monograph Number 5.

Second National Conference on World Health

The American Geophysical Union was represented at the Second National Conference on World Health held May 7-9, 1959 by Louis F. Warrick and Walton H. Durum. The Conference was sponsored by the National Citizens Committee for the World Health Organization, with the collaboration of more than two hundred health, educational, welfare, civic and business organizations. The Conference discussed important international health legislation pending before Congress, considered the value of international health programs in generating habits of cooperation among nations on other, non-controversial matters, and—taking a cue from IGY—outlined the potentialities of a future International Health Year.

Leaders, both governmental and non-governmental concerned with health problems, stressed benefits to be derived through a 'Health-for-Peace Crusade.' Means for strengthening the program of the World Health Organization of the UN, were emphasized in the discussions in view of indicated increased needs for reliance on WHO in the future in international programs for better health.

The advocated plan for an International Health Year was formally proposed at the meeting of the World Health Organization in Geneva the week

following the Conference. Attention would be focused on certain world-wide health needs; emphasizing for instance, the eradication of small pox, tuberculosis, or other such communicable disease. Modern health and sanitation procedures would be widely demonstrated and featured in every way practical. The period suggested for the International Health Year is beginning at the World Health Assembly in May 1961 extending through 1962, with a final 'roundup' report at the time of the World Health Assembly in May 1963.

Prepared by LOUIS F. WARRICK
Subscribed to by WALTON H. DURUM

International Union of Geodesy and Geophysics
Scientific Meetings Scheduled for 1960

Chiefly in connection with the Twelfth General Assembly, Helsinki, Finland, July 25-August 6

Word of the following scientific meetings scheduled for the year 1960, has been received from the General Secretary of IUGG. The names of the sponsoring associations are given parenthetically.

1. Geodetic and geophysical study of data furnished by rockets and artificial satellites (the Union as a whole). The various geodetic and geophysical problems will be studied in the light of results of observations of rockets and artificial satellites. Among the problems selected are the following: the determination of the flattening of the Earth, the study of the Earth's gravitational field, and the improvement of numerical values of constants concerning this field. Furthermore, the meteorological data furnished by artificial satellites and the information obtained by rockets and artificial satellites for the study of the higher atmosphere will be examined. General studies of radiation and cosmic rays will also be included.

The meeting will take place in Helsinki on July 29, 1960. The number of participants anticipated is approximately 300. Publication will be handled by the General Secretary of the IUGG, G. Laclavere.

2. The mean level of seas in Europe (International Associations of Geodesy and of Physical Oceanography).

The object of the meeting will be the study of the results obtained by the joint consideration of the European surveying network (Western and Northern Europe). The meeting will proceed to the discussion of results obtained for the altitudes of mean sea level for each of the tide-gages used in research.

The meeting will take place at Helsinki during the course of the General Assembly of the IUGG, July 30, 1960. The organization has been assigned to Professor P. Tardi. The number of participants anticipated is around 100. It is planned to publish the communications presented at this meeting in the *Bulletin Geodesique*, issued by the International Association of Geodesy.

3. New adjustment of European triangulations (International Association of Geodesy)—During the course of this meeting a second phase of the rigorous adjustment of primary triangulations of Western Europe will be studied. Thanks to recent measurements, the data that have been used in the first adjustment can be improved. The meeting will determine the methods of calculating the adjustments.

The meeting will take place at Munich in the month of May 1960. The organization has been entrusted to Professor Max Kneissl, Geodatisches Institut, 21 Archistrasse, Munich. The number of participants anticipated is about 50. Communications presented at the meeting as well as the conclusions adopted will be published in the *Bulletin Geodesique*, issued by the International Association of Geodesy.

4. International Latitude Service (International Association of Geodesy)—The object of the meeting is to pinpoint the measurements considered in common with the International Astronomical Union for the organization and future program of the International Latitude Service.

The meeting will take place at Helsinki during the course of the General Assembly of the IUGG. The organization has been assigned to Professor P. Tardi. The number of participants anticipated is about 50. No plan has been made yet for the publication of the communications presented and the conclusions of the meeting.

5. Tsunamis and storm surges (International Associations of Seismology and Physics of the Earth's Interior, of Meteorology and Physics of the Atmosphere, and the Physical Oceanography). This meeting has been called at the request of the World Meteorological Organization, the Executive Committee of which at its meeting in Geneva in September 1957 considered the possibilities of establishing an international service of information concerning the formation and the movement of tsunamis. The three Associations cited have decided to organize a symposium at Helsinki in 1960 devoted to focusing on the studies of tsunamis and storm surges: origin, propagation, distinction between tsunamis of seismic origin and of meteorogical origin, functioning of the services of alert, and eventual extension of these services. The subject is of obvious concern: it is a question of studying the protection for coastal populations menaced by tsunamis.

The organization of the meeting has been as-

signed to Professor J. P. Rothe. The number of participants estimated is about 40. A number of experts on these questions will be invited to present papers. Those considered are Captain E. B. Roberts (United States), Director Jack Murata, of the Hawaiian Volcano Observatory, Professor Galanopoulos (Athens), and Dr. Rossiter (United Kingdom). It is planned to publish the proceedings and communications of this meeting in the form of a monograph by the General Secretary of the IUGG.

6. Island arcs (International Associations of Seismology and Physics of the Earth's Interior, of Geodesy, and of Volcanology)—The structure and formation of island arcs bordering the Pacific is one of the fundamental problems of tectonophysics. This study involves gravimetric data (distribution and intensity of mass anomalies), volcanological data (alignment of chains of active and extinct volcanoes), seismic data (distribution of normal and deep focus), geological data (axes of Tertiary and Quaternary foldings). Numerous measurements have been carried out recently: gravimetric measurements, measurements of seismic refraction in the Sea of Okhotsk and in the Pacific Basin, study of seismic activity on Kamtchatka and the length of the Aleutian Islands. These recent studies make desirable a comparison of the ideas of geophysicists of the three Associations.

The meeting will take place at Helsinki, July 28, 1960. The organization has been assigned to Professor J. P. Rothe. The number of participants anticipated is about 60. Distinguished scientists will be invited to present papers, among them Professor Vening Meinesz (The Netherlands), Professor Wadati (Japan), Professor Richter (United States), Professor Gutenberg (United States), Professor Beloussov (USSR), and Professor Wilson (Canada). The proceedings of the meeting and the communications presented will be published in the form of a monograph by the General Secretary of the IUGG.

7. Atmospheric chemistry and radioactivity (International Association of Meteorology and Atmospheric Physics)—The International Association of Meteorology and Atmospheric Physics, recognizing the growing importance of the study of airborne particles and gases, radioactive and otherwise, decided at the General Assembly held in 1957 in Toronto to set up a commission for this field and to organize a symposium at the time of the General Assembly at Helsinki, 1960. As regards non-radioactive substances, the interest lies in their nature, origin and disposition and the role they play in clouds and rainfall. There are vital questions to resolve which have a bearing on the variation of climates and on the artificial stimulation of rainfall. As regards radioactivity, a paramount question is the intensity and position in different parts of the world and the mechanism by which radioactive material released at high levels is brought down to the Earth's surface. At the same time the results will contribute to the understanding of the circulation of the atmosphere. It is believed that by bringing atmospheric radioactivity into the field of study of meteorologists a very important contribution may be made to the understanding of the hazards introduced by the release of radioactive substances from reactors and weapons trials.

The Meeting will be held at Helsinki, at the time of the General Assembly of the IUGG. The exact date has not yet been selected. Dr. R. C. Sutcliffe is in charge of the organization of the meeting which will be a fully international symposium under the presidency of Prof. W. Bleeker of The Netherlands. The Secretary of the meeting will be Dr. C. E. Junge (United States). Some 16 papers will be invited and discussed. Any delegate at the General Assembly may attend the Symposium and over 100 participants drawn from virtually every country in the World may confidently be expected. The communications and discussions will be published by the Secretary of the International Association of Meteorology and Atmospheric Physics.

8. Dynamical processes in the atmosphere (International Association of Meteorology and Atmospheric Physics)—The most outstanding progress in weather forecasting in the last decade lies in the field of dynamical calculations using electronic computing machines for the integration of complicated differential equations. Problems of the general circulation of the atmosphere, long-range forecasting, and climatic change are now open to attack by these more exact methods. It was agreed at the General Assembly in Toronto, 1957, that a symposium on this subject should be held in 1960. The proposal was initiated by the U.S.S.R. delegation and the symposium, will bring together experts from many countries. The World Meteorological Organization is also much interested in the possible application of dynamical methods to the forecasting of high level winds and temperature demanded by the introduction of high-flying jet-engined aircraft. The symposium will therefore be of special interest to meteorologists gathered from all parts of the World at Helsinki.

The symposium will be held at Helsinki, at the time of the General Assembly of the IUGG. Dr. R. C. Sutcliffe is in charge of the organization of the symposium. The anticipated number of participants is about 100. No provision has so far been made for publication of the report of the symposium and of the communications presented.

9. On the regular variation in and distribution of the geomagnetic field and cosmic rays (International Association of Geomagnetism and Aeronomy)—A great effort has been made during the IGY to improve the knowledge of the Earth's magnetic field in conjunction with the study of cosmic rays. It is now necessary to synthesize data, to discuss them, and to draw from them orderly, scientific conclusions. Such is the aim of the meeting.

The meeting will take place at Helsinki during the General Assembly of the IUGG. It will be

organized jointly by Father J. O. Cardus (Spain) and Dr. V. Laursen (Denmark). The number of participants anticipated is about 80. Nothing has yet been decided concerning the publication of the proceedings of the symposium.

10. Polar wandering (International Association of Geomagnetism and Aeronomy, with the participation of the other Associations)—Under the assumption that the geomagnetic field throughout geological time has remained approximately a geocentric dipole field, the position of the Earth's magnetic poles has been derived from palaeomagnetic observations for several geological epochs since Precambrian times. During the geological ages there has been a considerable displacement of the magnetic poles thus determined, and since theoretical considerations and also palaeoclimatological evidence seem to support the assumption that the dipole axis has at any time coincided approximately with the axis of rotation, this would mean a moving of the Earth's crust relative to the geographical poles. However, palaeomagnetic observations from different continents give a different path for this apparent polar wandering, a fact which seems to be indicative of certain relative movements of the continents during the geological time.

The meeting will take place in Helsinki during the General Assembly of the IUGG. It will be jointly organized by Father Cardus (Spain) and Sir Edward Bullard (England). The number of participants anticipated is about 100. Nothing has been decided concerning the publication of the proceedings of the symposium and of the communications that will be presented.

11. World magnetic survey (International Association of Geomagnetism and Aeronomy)—It is evident that our knowledge of magnetism is not complete in many regions. In other regions, the work done on a national scale has not been correlated with the work of neighboring countries. On the other hand the impressive effort during the IGY not only utilized a great many magnetic observatories installed in regions that previously had been very poorly studied (polar regions, notably the antarctic and the equatorial zone) but also some new techniques: airborne magnetometers allowed the study of magnetic characteristics over large regions of the globe, and the non-magnetic ship *Zaria* (USSR) is completing her oceanic cruise that will undoubtedly furnish very important data on the magnetism in the oceans.

It appears then that the time has come to analyze the results in order to obtain a general view of magnetism of the entire globe. For these reasons the Association is planning the establishment of a magnetic survey on a world scale.

It is evident that the network of IGY magnetic stations leaves gaps that must be closed. Furthermore, in the case of observatories which serve as reference stations, it will be necessary to have some local measurements carried out by national magnetic services. Finally there remains the enormous work of calculation in a coherent and homogeneous way.

But the work will lead to a more complete understanding of the magnetism of our planet. This can be very useful not only from the theoretical point of view but also from the practical viewpoint: navigation by compass is not yet absolutely sure, and the work of magnetic prospecting be it for oil and minerals, or for subterranean waters, is becoming more and more common.

It will necessarily take time to assure effective collaboration of all the nations in order to coordinate the work and pinpoint the necessary techniques to study the oceans and the great desert or semi-desert regions of the globe. The Association has already charged its Committee of Magnetic Surveys to study the question and to establish a plan for proceedings that will be introduced, discussed, and probably approved at the Helsinki meeting.

The meeting will take place in Helsinki during the General Assembly of the IUGG. Father Cardus has been given the responsibility for its organizing. About 100 participants are expected. No action has been taken yet in order to provide for the publication of the proceedings and the communications presented.

12. Circulation of carbon dioxide in the atmosphere and ocean (International Associations of Physical Oceanography and of Meteorology and Atmospheric Physics)—The carbon dioxide theory of climatic change was abandoned a long time ago as it was believed that all the long-wave radiation absorbed by CO_2 is also absorbed by water vapor. However, this conclusion was based on early, approximate calculations of the radiation flux in the atmosphere. The results of more accurate calculations of the radiation flux that have recently become available appear to make it worthwhile to reappraise the CO_2 theory of climatic change. In recent years it has often been pointed out that mankind is just now carrying out a large-scale geophysical experiment, which is unique in so far that it will never be possible to repeat it, namely, the burning of the Earth's store of fossil fuel. It is believed that here lies the cause of the rise of the CO_2 concentration in the atmosphere observed during the last three quarters of a century. It has been suggested that this might influence the climate. Under the circumstances, it is a paramount interest to forward the study of CO_2 in the Ocean and Atmosphere.

The symposium will be held in Helsinki on August 3, 1960. Prof. B. Kullenberg is in charge of the organization of the meeting. It is anticipated that about 100 participants will attend. The proceedings of the meeting and the papers presented will be published in the collection of the *Publications Scientifiques de l'Association Internationale d'Oceanographie Physique;* Prof. B. Kullenberg will be the editor.

13. Variation in the flow over submarine ridges —Iceland and Greenland Ridges (International

Association of Physical Oceanography)—The problem of the overflow of arctic water at the Iceland-Faroe ridge (and, also, the Greenland-Iceland ridge) has attracted much attention by the Hydrographic Committee of the International Council for the Exploration of the Sea in the last three sessions, and there is no doubt at all that an international attempt at studying the overflow at the Iceland-Faroe ridge will be made in 1960. There will be eight or nine ships, namely, two each from Germany and Norway and one each from Denmark, Iceland, Scotland, Sweden, and USSR, perhaps also a vessel from England. The project has been recommended by the Hydrographic Committee of the International Council for the Exploration of the Sea, at its meeting in September-October 1958. The following resolution was passed:

> "The Hydrographical Committee recommends that the multi-ship investigations on the Iceland-Faroe Ridge as proposed for the month of June 1959 should be postponed until June 1960 in order (a) to allow time for the development of various mechanical or servo-mechanical recording apparatus which is now in progress, and (b) to derive maximum advantage from the results of the IGY investigations. At the same time the Committee recommends the continuance or repetition during 1959 of such significant investigations as those described in papers to the 1958 meeting of the Hydrographical Committee by Messrs. Steele, Tait, Carruthers, and Lee."

Recent investigations of the thermo-haline stratification on a selected profile across the Greenland-Iceland ridge and across the Iceland-Faroe ridge as well as the repetition of these profiles at a later time have yielded a remarkable result. The two submarine ridges are overflowed by arctic deep water coming from the Norwegian Sea and having a low temperature (0°—5°C). This fact has been known since the great Danish "Ingolf" expedition 1895–96 through investigations made by Martin Knudsen. Above this, more recent observations indicate that this overflowing does not take place continuously. There seem to occur great changes, with time, which might be accomplished within a few days. Besides, the overflowing does not seem to extend over the full length of the ridges, but appears to confine itself to especially favored sections of the ridges. The object of this proposal is that more attention should be paid (in addition to observing the inflowing water masses at the right-hand side of the channels into the Norwegian Sea) to the flowing-out process.

There is a large scientific interest in clearing the overflowing processes across the two submarine ridges. Special attention should be directed to ascertain as completely as possible the variations in the acts of overflowing and to reveal their causes and effects.

The effects of such variations can be of great importance in two respects, each being worth an intensive investigation. (a) It is a known fact that the arctic deep water of the Norwegian Sea, which enters across the two submarine ridges the North Atlantic Ocean, sinks because of its high density, becoming the bottom water in the great depths of the northern part of both the West Atlantic trough and the East Atlantic trough. If the renewal of this bottom water takes place by pulses, as it seems to do according to recent observations, then these pulses must have an effect on the circulation in the deep layers of the northern North Atlantic Ocean. (b) If there are greater variations in the overflowing of the submarine ridges, then these must manifest themselves above the ridges in shiftings of the boundaries of water masses of different origin. Both submarine ridges belong to the principal fishing grounds of the European fisheries. From fishing it is known that the catches on the same ground may change within a few hours, so far without any recognizable cause. It might be assumed that interrelations between this phenomenon and the variations in the acts of overflowing of the arctic water of the deep layers exist.

The proposed investigations may essentially contribute towards an understanding of the circulation in the deep layers of the North Atlantic Ocean. They may give at the same time important hints to fishery in connection with the yields of the submarine ridges.

The results so far obtained and their discussion are the essential theme of the proposed symposium.

The symposium will be held in Helsinki at the time of the General Assembly of the IUGG. Dr. J. B. Tait (Scotland) is in charge of the organization. The presence of 60 participants is anticipated. The proceedings and the communications presented will be published in the *Procès Verbaux de l'Association Internationale d'Océanographie Physique*, Dr. J. B. Tait being the editor.

14. Ocean circulation (International Association of Physical Oceanography)—The problems on the oceanic circulation attract, at present, more attention than any other field in physical oceanography. Developments have been very rapid in the collecting of data as well as development of the theory. A symposium on ocean circulation at Helsinki in 1960 will come soon after the one at Toronto but there are, nevertheless, very good reasons to take up the subject anew.

During the Geophysical Year a tremendous amount of data has been collected, and it is essential that these shall be considered very promptly. A careful mixture of information obtained from the new oceanographic sections, the float measurements using Swallow's devise, and an outline of the most recent theoretical developments cannot fail to be profitable.

The symposium will be held at Helsinki at the time of the General Assembly of the IUGG. Professor B. Kullenberg is in charge of its organization. The anticipated number of participants is about 100. The proceedings and the communications presented will be published in the *Procès*

Verbaux de l'Association Internationale d'Océanographie Physique; Professor Kullenberg being the editor.

15. Optics of the sea (International Association of Physical Oceanography)—Optics of the sea is a branch of physical oceanography which has been in rapid progress for a number of years. Several contributions have been made to our knowledge of under-water daylight and associated polarization phenomena which exert an effect on aquatic organisms. Diffusion processes may readily be studied by transparency measurement, and the particle distribution in the ocean, which is related to the production as well as to the dynamics of the ocean, is obtained from light-scattering observations.

There is a wide-spread opinion among oceanographers working in this field that the time is ripe to discuss current problems by arranging a symposium on the optics of the sea, the program of which should aim at establishing suitable signs and symbols, discussing instrumentation and its standardization, drawing up the contours of our present knowledge in the field and recommending lines on which future research should proceed.

The symposium will be held at Helsinki at the time of the General Assembly of the IUGG. Dr. N. Jerlov (Sweden), is in charge of the organization, with the assistance of Dr. Waterman, Dr. Ivanof, and Dr. Joseph. These four scientists have been invited to present contributions to the symposium. The anticipated number of participants is about 60. The proceedings and the communications presented will be published in the collection of the *Publications Scientifiques de l'Association Internationale d'Océanographie Physique;* Prof. B. Kullenberg will be the editor.

16. Chemical oceanography (International Association of Physical Oceanography)—Following on a proposal by the USSR Committee for the IGY, the problems concerning standardization of chemical methods of sea-water analysis, and chemical units in oceanography, were put on the agenda of the General Assembly of the International Association of Physical Oceanography at Toronto. The deliberations at the General Assembly led to the formation of a scientific Committee on Chemical Oceanography, the terms of reference of which contained the following paragraph: "To organize one or more symposia to be presented in Helsinki in 1960 on a chemical theme or on a theme connecting chemical oceanography with another activity of IUGG." As developments within the field of chemical analysis in oceanography have proceeded for a long time without international coordination, it appears that the necessity of organizing a symposium on Chemical Oceanography should be easily recognized.

The symposium will be held at Helsinki at the time of the General Assembly of the IUGG, Dr. L. H. N. Cooper (England). The anticipated number of participants is about 60. No decision has yet been taken concerning the publication of the symposium. It has however been suggested to publish it in the collection of the *Publications Scientifiques de l'Association Internationale d'Océanographie Physique.*

17. Ocean floor (International Associations of Physical Oceanography and of Seismology and Physics of the Earth's Interior)—At the General Assembly at Toronto the A.I.O.P. appointed a scientific Committee on the General Bathymetric Chart of the Ocean whose terms of reference are: "To promote the preparation of an up-to-date chart of the bottom topography of the oceans in liaison with the International Hydrographic Bureau and International Council of Scientific Unions." There can be no doubt about the very great importance of a bathymetric chart of the oceans for the study of physical oceanography and marine geology. To make the best use of the large amount of data accumulated, the Committee feels that they need the guidance that should be given by a Symposium on the Topography, Morphology, and Geology of the Ocean Floor. Such a symposium should offer opportunity (1) of bringing forward new information, (2) of obtaining scientific viewpoints for the shaping of the General Bathymetric chart of the Ocean, and accelerating the creation of a new bathymetric chart of the Ocean. Apart from this, the Symposium should attract very general attention in view of the rapid progress in the field of marine geology.

The symposium will be held at Helsinki, on July 28, 1960. Prof. B. Kullenberg is in charge of the organization of the symposium. The anticipated number of participants is about 60. The symposium will be published in the collection of the *Publications Scientifiques de l'Association Internationale d'Océanographie Physique;* Prof. B. Kullenberg being the editor.

18. Mapping of subterranean waters (International Association of Scientific Hydrology)—During the General Assembly at Toronto, the first exchange of views took place on the methods of drawing maps of subterranean waters and the information that they can furnish. These discussions showed widespread interest in this question and it was decided to call a meeting of representatives of many countries, particularly of arid zones (Morocco, Algiers, and Tunis have already shown their interest in this question). It was further decided to report on actual accomplishments at Helsinki at the same time as the conference on the method of preparing these maps. In addition to the countries of the arid zones mentioned, a number of countries (Germany, Belgium, the U. S., The Netherlands . . .) have, as of the present, decided to take part in this scientific session.

The symposium will take place at Helsinki, July 30, 1960. Professor L. J. Tison will be in charge of its organization. The anticipated number of participants is between 30 and 40. Publication of the Symposium will be handled by Professor Tison in the collection of publications of the International Association of Scientific Hydrology.

19. Tidal rivers (International Associations of Scientific Hydrology and of Physical Oceanogra-

phy)—The maritime part of the river (that which is subject to tide) poses multiple and generally very difficult problems: variations of heights and currents caused by the tide, influence of up-stream supply, influence of the form of estuaries, action of storm surges, problems of sedimentation, questions of salinity, etc. The solution of these problems is however, of primary importance to the economic life of many countries: the estuaries are in general places of predilection for the introduction of maritime navigation in the heart of lands, determining key sites for trade with the outside. The agriculture of these riparian regions also poses problems of more or less pronounced salinity of waters and of deposits. These estuaries are encountered in all the regions of the globe and those of young countries will be able, without or after regulating, to play a role analogous to those more developed regions. It is by means of these estuaries that civilization has penetrated and it is through them that passage of imports and exports are actually concentrated. But these estuaries pose complicated problems. Their maintenance and preservation can be devised only by precise knowledge of movements of sea-tide and the fluctuations that it provokes. The study of these movements and those that superpose themselves and produce currents of density which are due to influences of the wind, etc. has advanced exceedingly in the course of late years. It is important, therefore, to profit from the information of oceanography and hydrology to make progress in this domain.

The meeting will take place in Helsinki, July 28 and 29, 1960. Professor L. J. Tison and Professor B. Kullenberg will jointly be in charge of the meeting, which will be published in full in the collection of publications of the International Association of Scientific Hydrology.

20. Study of low stream flow and droughts (International Associations of Scientific Hydrology and of Meteorology and Atmospheric Physics)—The program of this symposium is as follows:

A. Hydrological study
   1. Study of low-water supply
      (a) Annual mean low-water flows
      (b) Correlation of the low-water with the periods without rain, the geological nature of the soils, and the temperature (winter level)
      (c) Value of coefficients of flow during periods of low-water
   2. Study of flow arising from snowy periods
      (a) Flow during the cold season
      (b) Flow during the melting period

B. Study in cooperation with meteorologists; droughts
   1. Characteristics; meteorological causes
   2. Frequency of appearance; forecasts
   3. Spatial distribution of periods of droughts (large scale)
   4. Droughts in history and in the last geological era; correlation of this question with that of the birth and existence of arid zones.

The program in question would allow participation of all the commissions of both Associations. The entire question, particularly the study of droughts, is the most interesting in the arid zones. In effect, actually, it is necessary to rely upon, even for the study of Part A of this program, the presentation of results of measurements and research giving an account of habitually dry regions and developing their characteristics. The flow proceeding from snowy regions frequently has great interest for arid zones whose waters come chiefly from melting snow. But it is evident that Part B (Droughts) will generally have the greatest interest for the arid zones.

The symposium will take place at Helsinki, July 27 and 28, 1960. It will be organized by Professor L. J. Tison. The anticipated number of participants is between 30 and 40. The proceedings of the symposium and the text in full of the communication presented will be published in the collection of the publications of the International Association of Scientific Hydrology through the efforts of Professor L. J. Tison.

21. Relation of volcanoes and batholiths (International Association of Volcanology)—The object of this symposium, which is of interest to all geologists, is to bring about studies of relations that can exist between volcanoes and batholiths in the light of regional examples.

The symposium will take place at Helsinki during the General Assembly of the IUGG. It will be organized by Professor F. Signore. The number of participants anticipated is around 50. The proceedings will be published in *Bulletin Volcanologique* through the efforts of Professor F. Signore.

22. Study of volcanic gas (International Association of Volcanology)—The questions that will be studied during this meeting can be summarized as follows: study of volcanic gas by spectro-analytical methods on active volcanoes, research of the operations for the collection of magnetic gases out of active volcanoes, complete study of these gases, including their isotopic composition and the presence of tracer elements.

The symposium will take place at Helsinki during the General Assembly of the IUGG. It will be organized by Professor F. Signore. The number of participants anticipated is around 50. The proceedings and the communications presented will be published in *Bulletin Volcanologique* through the offices of Professor Signore.

More complete information on these and other meetings will be published from time to time in *Chronique de l'UGGI* as it is received at the office of the General Secretary of the IUGG.

SPECIAL ANNOUNCEMENTS

MEETING OF THE PACIFIC NORTHWEST REGIONAL GROUP—The Pacific Northwest Regional Group will hold its meeting November 5 and 6, 1959 at Corvallis, Oregon. Interested persons should get into touch with Wilbur D. Simons (U. S. Geological Survey, 529 Perkins Building, Tacoma, Washington), who, as Chairman of the year just closed, is in charge of organizing the Committee for this meeting and the coming triennium.

PACIFIC SOUTHWEST REGIONAL MEETING—Plans are developing for the Pacific Southwest Regional Meeting to be held at the University of Southern California, February 4 and 5, 1960. The new Chairman of the Regional Committee is Eugene N. Bollay and the new Secretary is W. D. Duthie. In charge of the meeting at the University of Southern California is Stanley Butler.

FORTY-FIRST ANNUAL MEETING OF THE AMERICAN GEOPHYSICAL UNION—The Forty-First Annual Meeting of the AGU will be held in Washington, D. C., on the Thursday, Friday, and Saturday following the meeting of the National Academy of Sciences, probably April 28-30, 1960. Watch Special Announcements for later information as well as a possible change in dates.

This is a first call for the titles and abstracts of papers and suggestions for symposia and other matters relating to the meeting to be sent to Philip H. Abelson, (2801 Upton Street, N.W., Washington 8, D. C.), Chairman of the Committee on Meetings; to the Office of AGU (1515 Massachusetts Avenue, N.W., Washington 5, D. C.); or to the appropriate Section Secretaries. The new Secretaries are listed in the June issue of the *Transactions*, page 140.

TWELFTH GENERAL ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS—The program plans for the Twelfth General Assembly are rapidly taking shape. This General Assembly will be held in Helsinki, July 25 to August 6, 1960. Any citizens of the United States or any persons in residence in the United States who plan to attend or to present papers should get in touch with the AGU for detailed information concerning the plans and to receive information concerning accommodations and other matters released by the Finnish Organizing Committee from time to time. It is noted in the March issue of the *Transactions* (page 40) and the June issue (page 156) that the Finnish Organizing Committee is working out arrangements for a very interesting sojourn.

Special attention is called to the information immediately preceding these Special Announcements in this issue of the *Transactions* concerning scientific meetings scheduled for 1960 by the International Union of Geodesy and Geophysics chiefly in connection with the Helsinki meeting. Attention is also called to the Special Announcement in the June issue of the *Transactions*, pages 156 to 159, of the plans of the Section of Hydrology and the means by which these plans are to be implemented.

Vol. 40, No. 3 TRANSACTIONS, AMERICAN GEOPHYSICAL UNION September 1959

NATIONAL ACADEMY OF SCIENCES

Number 25 • July 1959

IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation-1959 as related primarily to United States programs.

Observation of Solar Cosmic Rays

The following material was prepared by P. S. Freier, E. P. Ney, and J. R. Winckler, of the School of Physics, University of Minnesota. A more detailed report was published in the Journal of Geophysical Research, *June 1959.*

A very unusual series of solar and terrestrial phenomena occurred in late March 1958, culminating in the arrival at the earth of low-energy cosmic rays. These events probably resulted from a solar flare of importance 3+ (the highest category of importance, indicating flares covering more than 1200 millionths of the sun's visible hemisphere); this flare began at 0950 UT, March 23, and ended about four hours later.

The flare was followed immediately by an extremely severe radio-noise storm on the sun. This storm produced radio emissions at all observed frequencies, from about 170 to 9400 megacycles, and a short-wave radio fadeout, which occurred between 0953 and 1309 UT, March 23. (J. F. Denisse, of Meudon Observatory, Paris, reported that at the lower frequencies the storm was one of the largest and longest ever recorded.)

The sudden commencement of a geomagnetic storm at 1540 UT, March 25, signaled the arrival at the earth of the cloud of solar gas presumably ejected by the flare. This was followed shortly by a pronounced decrease in cosmic-ray intensity at sea level.

Balloon Observations

High-altitude balloon data were obtained on the energy and composition of cosmic rays during the period of disturbance near Minneapolis (geomagnetic latitude 55°N). Balloon flights designated IGY 27, 28, and 29 were made on March 21 and 26 and on April 8, respectively. The balloons carried single counters and ion chambers, which record continuously the particle flux and the atmospheric ionization, and photographic emulsions for determining the precise nature of the particles involved.

Counting Rate and Ionization Intensity: Figure 1 presents the results of these measurements at an atmospheric pressure level of 10 millibars (about 102,000 ft). The ion-chamber curve shows constant and steady ionization on March 21 and a return to this condition by April 8. On March 26, however, the intensities measured by the single counter and ion chamber as the balloon reached peak altitude, at 1300 UT, were about 23% less than the March 21 values. This is consistent with the "Forbush decrease" in cosmic-ray intensity following a solar flare. (These decreases are now thought to indicate the modulating effect of the beam of solar particles on pre-exist-

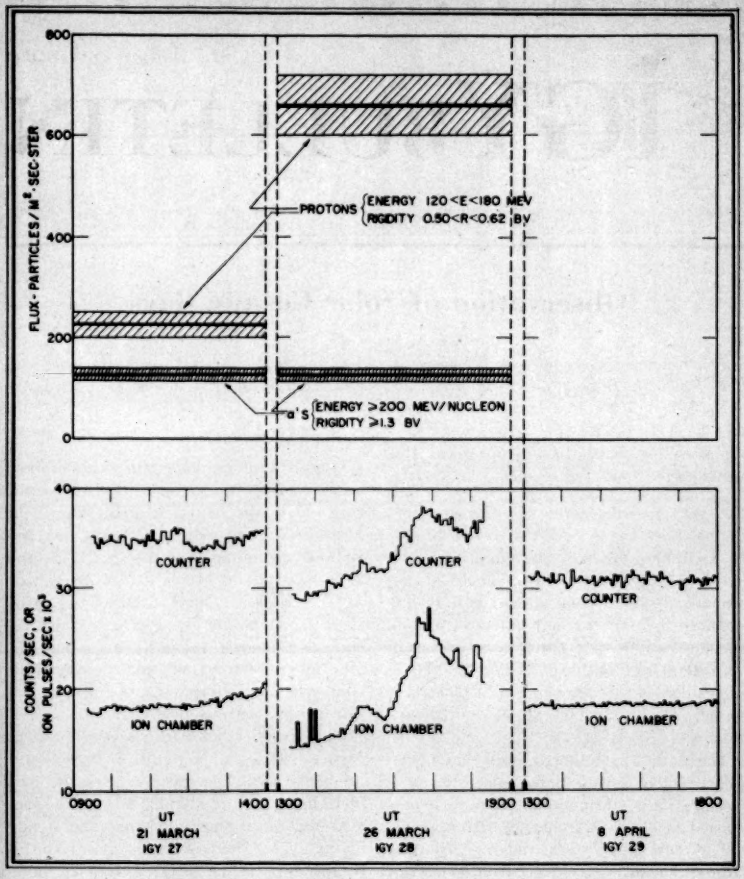

Fig. 1. *Counting Rates, Ionization, and Particle Composition as Measured on IGY Balloon Flights 27, 28, and 29. Upper part shows alpha-particle and proton flux measured by nuclear emulsions; lower part shows counting rates and ionization. The increase in ionization rate on March 26 agrees satisfactorily with the proton-flux increase shown by emulsions carried on the same flight.*

ing cosmic rays, causing a drop in intensity both at sea level and at high altitudes.)

On this occasion, the Forbush decrease was followed, about an hour after the balloon had reached ceiling altitude, by a slow *increase* in counting rate and in ionization. This continued throughout the remainder of the flight, a period of six hours. From

analysis of the ratio of ion-chamber to single-counter readings it was determined that if the ionizing particles were protons their range was 33 gms/cm² (i.e., they would penetrate any material to a thickness at which a cm² column would weigh 33 gms) and their energy was about 200 million electron volts (mev).

(It is possible that the increase with time of counting rate and ionization during the IGY-28 flight may actually represent a latitude effect, since the balloon drifted from Minneapolis to Sault Ste. Marie, Michigan. No increase was observed in a simultaneous flight in Texas, at geomagnetic latitude 41°N.)

Nature of Particles: Detailed studies were made to determine the nature of the particles associated with this increase in cosmic-ray intensity. The upper part of Figure 1 shows the results of observations of alpha particles (He^{++}) with energies greater than 200 mev/nucleon (equivalent to a total energy of 800 mev/alpha particle) and of protons (H^{+}) with energies of 120-180 mev. (Protons are believed to make up about 90% of primary cosmic rays, with heavier particles, including alpha particles, comprising the remainder.) The equipment used measured almost all alpha particles but only protons of rigidities between 0.50 and 0.62 BV. (Magnetic rigidity = momentum/charge, and is a measure of the resistance of the particle to deflection by a magnetic field; here, expressed in billions of volts, or BV.)

It was found that the flux of alpha particles of rigidity greater than 1.3 BV did not change measurably, but the flux of protons within the narrow rigidity range measured increased by the large amount of 0.04 particles/cm²·sec·ster. At solar maximum, the total particle flux is about 0.1 particles/cm²·sec·ster, i.e., 0.1 particles pass through a cm² area each second from directions lying within a three-dimensional angle of unit area, or steradian. The average increase in flux for the IGY-28 flight was, therefore, nearly half the total primary proton flux. This increase is consistent with the flux of protons of energies below 200 mev estimated from the ion-chamber to single-counter ratio, which was .06 particles/cm²·sec·ster. During the event, protons arrived with rigidities as low as 0.5 BV, far below the rigidity cut-off of 1.0 BV for this geomagnetic latitude, inferred by P. Fowler, P. S. Freier, and E. P. Ney from previous direct-energy measurements. (Normally, only the higher-energy particles can penetrate the earth's magnetic field at the equator; lower-energy particles can penetrate only to certain geomagnetic latitudes, depending on their energies; very low-energy particles can penetrate only in polar regions.)

Sea-Level Intensity

A plot of sea-level neutron intensity at Deep River, Canada, March 20–April 10, is shown in Figure 2. In the period March 25–26 a drop in intensity of nearly 10% was measured, but it can be seen that the counting rate recovered from the decrease by early April. (These data were obtained by H. Carmichael.)

Cosmic-Noise Absorption

Data on the cosmic-noise absorption at Fort Yukon, Alaska, associated with the cosmic-ray phenomena described was supplied by H. Leinbach and G. C. Reid (Fig. 2, bottom). They report a very large absorption, amounting to 10 decibels, beginning abruptly on March 26 at the time of the sudden commencement of the magnetic storm. Even at night, on the nights preceding and following March 26, the absorption of cosmic noise was 3 db.

It is thought that this type of polar-cap cosmic-noise absorption may be caused by the arrival at the earth of charged particles, increasing ionization in the D-region of the earth's ionosphere. The particles appear to have been confined to the solar beam, since they were observed only when the earth entered the beam, at 1540 UT, March 25. The

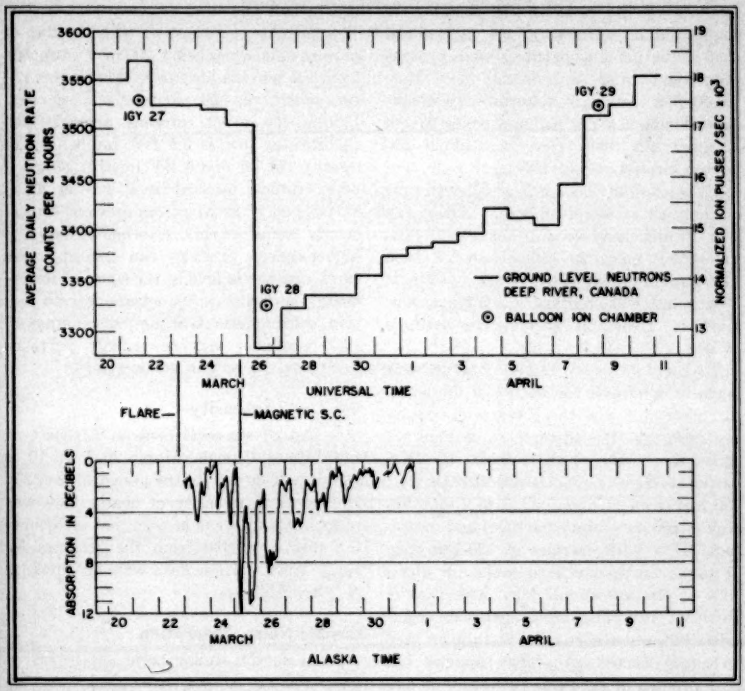

Fig. 2. *Sea-Level Neutron Intensity at Deep River, Canada, and Cosmic-Noise Absorption at Fort Yukon, Alaska. The neutron-intensity record also shows the total ionization rate at balloon ceiling altitude for IGY 27, 28, and 29.*

March 1958 disturbance may be the most intense event of this type observed up to that time.

(A second and even more intense event of this type was observed on May 11–12, 1959. The Minnesota investigators were informed by H. Leinbach that cosmic-noise absorption had reached 17 db on May 11. Accordingly, on May 11 and 12, five balloon flights were made. The observations showed that the May 11 event produced at least 50 times as many particles at balloon altitudes as were observed in the March event. In the more recent event, the solar beam apparently consisted almost entirely of protons.)

Conclusions

The significant features of this event are (1) the presence of particles with rigidities lower than the normal cut-off rigidity for the geomagnetic latitude of Minneapolis, and (2) the delayed arrival of cosmic rays following the solar flare of March 23.

The University of Minnesota investigators believe that the presence of low-rigidity

particles indicates distortion of the Stoermer cut-offs (the minimum particle energies needed to penetrate the geomagnetic field) by the solar beam ejected by the flare. They believe also that the late arrival of cosmic rays indicates storage in the solar corona of particles accelerated during the solar flare of March 23. The storage may have taken place between March 23 and March 30 and the particles may have arrived at the earth after being diffused into the magnetic channel associated with the solar beam.

Two other possible causes for the late arrival of the cosmic rays were considered: (a) The flare of March 23 produced a magnetic channel; subsequent solar activity accelerated the cosmic rays and injected them into the channel. This was ruled out because no major flares occurred in the period following March 23 to effect the acceleration and injection. (b) Particles trapped in the Van Allen radiation region (see *Bulletin No. 21*) were released by magnetic perturbation caused by the solar cloud. This was deemed improbable because of the polar-cap cosmic-noise absorption effects reported by Leinbach.

Rocket Studies of the Equatorial Electrojet

The following report is based on material supplied by Laurence J. Cahill, Jr., of the State University of Iowa. A more detailed account has been published in the Journal of Geophysical Research, *May 1959.*

Variations of the earth's magnetic field, long observed at the surface, are believed caused by electrical currents flowing in the ionosphere. However, the height, thickness, and current-density structure of these currents cannot be determined solely by ground-level measurements. Hence, the State University of Iowa included in its program of upper-atmosphere research the development of a small, light-weight magnetometer for use in rockoons. (*Bulletin No. 11* contains a brief description of the instrumentation and of the rockoon technique—which employs a balloon to lift a rocket to firing height.)

Successful flights were made during the IGY in both polar regions and in the mid-Pacific (Line Islands region), where the existence of the equatorial electrojet (see *Bulletin No. 17*) was further confirmed by direct measurements. This report is concerned with the equatorial electrojet studies.

The height and current density of the electrojet were measured at several latitudes during periods of magnetic calm and of moderate disturbance. In addition to the current layer previously predicted on the basis of ground-level measurements, another current layer was discovered slightly above the main electrojet current, and still another, flowing in the opposite direction, was found to the north.

The equatorial rockoon-magnetometer flights were made possible through the cooperation of Navy Task Force 43. SUI workers accompanied the USS *Glacier* on its cruise from Boston to the Antarctic during the Deep Freeze III expedition; in addition, the *Glacier* was allowed to deviate from its normal course for the Line Islands launchings and Navy personnel assisted with the launchings. Various SUI scientists, J. A. Van Allen in particular, supplied guidance and assistance in formulating the experiment, preparing the instrumentation, launching the rockoons, and reducing data.

Theory

The idea that variations in the earth's magnetic field observed at the surface are related to horizontal electric currents in the upper atmosphere is part of the "dynamo theory" of magnetic-field variations. In this theory, charged atmospheric particles are moved in tidal winds across the lines of force of the magnetic field, thus inducing electromotive forces in a direction perpendicular to the magnetic field. These electromotive forces cause positive and negative particles to move in opposite directions, setting up a system of electric currents in the atmosphere. Since the charged particles are provided by the horizontal ionospheric layers, the currents must likewise be principally horizontal. The tidal winds are related to the sun's movement across the sky; hence, the electrojet is primarily a day-time phenomenon.

The density of the electric current at any altitude above the surface depends on the velocity of the tidal winds producing the electromotive forces, the ionospheric conductivity at that altitude, and the strength of the magnetic field. Detailed information has in the past been lacking about the first two of these factors. Moreover, it seems likely that such information will for some time remain insufficient for detailed computation of the electric currents on the basis of the dynamo theory. However, the rocket magnetometer makes it possible to measure current densities directly and, along with electron-density measurements made by other rocket techniques, is supplying data which will help in computing conductivity more accurately.

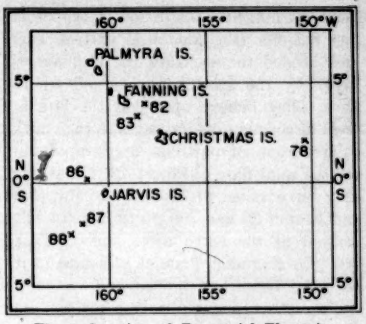

Fig. 3. *Location of Equatorial Electrojet Rockoon Flights, in the vicinity of the Line Islands.*

Flight Results

Six successful flights of the rocket magnetometer were made in the vicinity of the Line Islands (see Fig. 3 and Table 1). The records of three of these flights showed a normal approximate inverse-cube decrease with altitude in the intensity of the earth's magnetic field. The other three, flights 83, 86, and 87, apparently penetrated current layers in addition to recording the inverse-cube decrease.

The Scripps Institution of Oceanography established three ground-level magnetic ob-

Table 1. Flight Summary

Flight No.	(Oct. 1957) Date	Launching Time (at 165°W) Balloon	Launching Time (at 165°W) Rocket	Location	Peak Alt. (km)
78	14	1216	1331	2°16′N, 150°23′W	113
82	17	1101	1216	3°56′N, 158°07′W	51
83	17	1244	1359	3°23′N, 158°41′W	127
86	18	1243	1356	0°02′N, 160°52′W	122
87	19	0750	0907	2°05′S, 161°05′W	129
88	19	1406	1519	2°31′S, 161°26′W	104

servatories in the Line Islands during the IGY to obtain new information about the equatorial electrojet through simultaneous observations at separate locations. These observatories supplied necessary information about the degree of magnetic disturbance during flights near them. Moreover, the rocket and ground-level measurements complemented each other: ground measurements supplied information on short and long-range changes in current intensity and on the location and periodic movements of the center of the current; rocket measurements provided a comparatively detailed picture of the extent in latitude and altitude of the electrojet and of its structure—the profile of current density with altitude.

East-West Current: Flight 83, in the electrojet region but somewhat to the north of the electrojet itself (Fig. 3), provided accurate and fairly complete data to a height of 125 kilometers, well into the ionosphere. The flight record shows an abrupt change of slope at 104 kilometers, indicating penetration of a current sheet. This slope change is a decrease, however; hence, the current must flow east-west in this region, directly opposite to the predicted direction of the equatorial electrojet. Since the flight curve resumes its original slope at 108 kilometers, the current sheet is rather thin. The record for the downward leg also shows the slope decrease at the same place that it appears on the upward-leg record, supporting the existence of this east-west current.

There is some evidence that this current is quite limited in lateral extent and would produce only very small ground-level effects, even in the absence of the masking effect of the more powerful electrojet.

Figure 4 is a plot of current density against altitude computed for part of flight 83, showing the east-west current layer detected during the flight.

Electrojet Flights: Flight 86 was launched 30 miles northwest of the Jarvis Island magnetic observatory at 1356 local time.

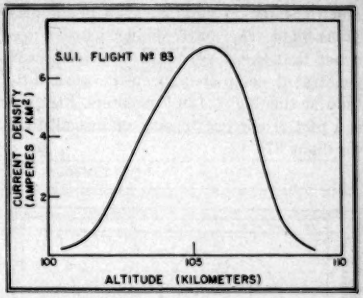

Fig. 4. *Current-Density Plot for Flight 83.*

Since ground-level measurements indicate that the electrojet appears to be closer to this observatory than to the others, it was expected that a launching at this location and time would result in penetration of the electrojet current.

The flight record shows an increase in slope at a height of 97 kilometers and a return approximately to the original slope at 110 kilometers, indicating that the rocket had passed through the electrojet in this region. (A rocket flight made during studies conducted by S. F. Singer and others in 1949 also entered the electrojet at approximately the same height.) Detailed plots of the flight record, however, reveal that above 110 kilometers the slope does not return entirely to its value at lower levels and that it again increases near 117 kilometers. Thus, two distinct current layers are indicated, with a layer of lower current density between them. Since the slope does not return completely to the lower-level value at the peak altitude reached by the rocket, 122 kilometers, the upper layer evidently was not completely penetrated.

The records for flight 87, southwest of Jarvis Island, also indicate penetration of the two current layers. The lower layer was found to be at the same altitude as in flight 86, but the upper layer was slightly higher. The current intensities were found to be

much greater on flight 87 than in the previous flight. There is some inconclusive evidence that the upper layer may have been penetrated completely near the peak altitude of this flight, 129 kilometers. Figure 5 is a plot of current density against altitude for flight 87.

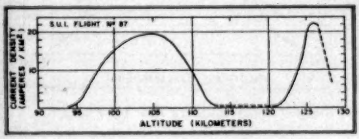

Fig. 5. *Current-Density Plot for Flight 87. Note two peaks, representing upper and lower current layers of electrojet.*

Intensity and Structure of Electrojet

Records from flights 83, 86, and 87, taken together with corresponding records from the Line Islands observatories, were used to sketch the intensity and structure of the equatorial electrojet.

Intensity: The departure from the normal inverse-cube decrease at the peak altitude of flight 86 was 138 ± 10 gamma (γ). (The sea-level magnitude of the earth's magnetic field at the equator is 34,000γ.) The contribution of the current sheet to the daily magnetic variation at sea level, as estimated from the rocket measurements, is 59 ± 4γ. This value, although in excellent agreement with the ground-level measurements, is surprising since the upper current layer was not completely penetrated. It is thought that only ⅔ of the value of the daily variation at sea level is attributable to the overhead current sheet (the Jarvis value was 90 ± 6γ at the time of the flight).

On flight 87, the total departure from the normal inverse-cube decrease at peak altitude was 300 ± 20γ, slightly more than twice that measured on flight 86. The expected contribution to the daily surface variation in this region is 127 ± 9γ, which does not agree with the value based on surface measurements (137 ± 4γ, or ⅔ the total measured value of 206 ± 6γ) quite as well as in the previous flight. This may be because ground measurements of overhead currents in the Jarvis region at the time of flight 87 indicated they were more intense than those found by rockets in the vicinity of flight 87, about 120 miles farther south.

Variograph records of the vertical component of the magnetic field (F) from Palmyra and Jarvis indicate local regions of more intense current imbedded in the electrojet. Although the main daily variation in F at these stations is similar, small, temporary fluctuations are opposite in phase. This indicates that the source of these small fluctuations lies between Jarvis and Palmyra. The center of the electrojet, however, appears to be south of Jarvis.

The currents measured up to heights of 129 kilometers appear to be of sufficient magnitude to account for all of the ground-level daily variations. However, it is believed there may be additional current layers above the peak rocket altitudes reached. Such currents might be too weak to produce observable variations at the ground, or they could be in pairs flowing in opposite directions, cancelling out each other's effects.

Structure: Figure 6 is a vertical cross-section of the equatorial electrojet based on extrapolations from the available experimental data. It is intended only as a graphic portrayal of the data and not as a precise or reliable picture of the actual electrojet.

The total width of the electrojet is estimated at about 300 kilometers, with the northern boundary lying between the sites of flights 83 and 86. (The width estimate agrees with a ground-level latitude survey by C. A. Onwumechilli, of the University of Nigeria, and with electrojet conductivity calculations by D. F. Martyn.) Flights 86 and 87, as well as earlier measurements by Singer and others, fix the bottom of the lower electrojet layer at a height of 97 kilo-

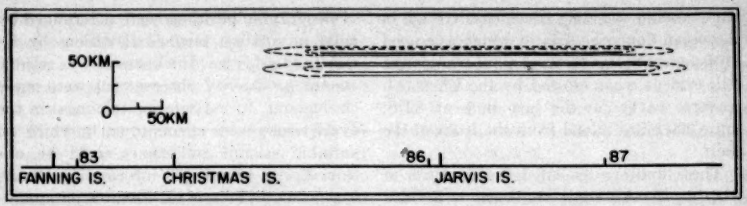

Fig. 6. *Cross-Section Showing Approximate Structure of Equatorial Electrojet. Inner lines represent regions of higher current density; numbers at bottom are flight numbers at their positions relative to the electrojet.*

meters. The top of the lower layer is at about 110 kilometers.

The lines within the layers in Figure 6 represent current-density regions, with density increasing toward the center of the layer. (Actual current densities vary daily and from day to day, and, as already mentioned, local regions of higher density may be present.) The altitude and thickness of the upper layer, as well as the interval between the two layers, appears to be variable.

Variations in the intensity and height of the upper layer may be related to the degree of magnetic disturbance or to several other factors, such as season, time of day, or phase of the moon. The flights described were made on both magnetically disturbed and on magnetically quiet days, shortly before the autumnal equinox, and when the moon was in the last quarter.

The presence of two current layers at the equator, rather than the single layer predicted from ground studies, must still be explained. A possible explanation is the presence of a high-electron-density layer above the altitude of peak ionospheric conductivity (near 100 kilometers). An intense sporadic-E reflection has been observed near the magnetic equator in the same region as the electrojet. (Sporadic-E refers to clouds, or patches, of ionization in the E-region of the ionosphere which reflect radio waves.) This sporadic-E layer could be responsible for one of the current layers, but which current layer might be due to the sporadic-E and which might be due to the peak in conductivity is not yet clear.

Antarctic Traverse Reports

Related materials from two sources bearing on the possible existence of a trans-Antarctic trough, along with other traverse findings, are presented in the following report. The first part of the report is based on a paper given at the May 1959 meeting of the American Geophysical Union (AGU) by Edward Thiel and Ned A. Ostenso. The second part is based on a paper presented by Charles R. Bentley and Ostenso at the same meeting. In both cases, the material was prepared at the University of Wisconsin.

I. AIRBORNE TRAVERSE, 1958–59

A principal result of the first season of IGY Antarctic oversnow traverse activity was the discovery that the Filchner Ice Shelf, which borders the Weddell Sea, extends much farther inland than had previously been supposed. Beneath its eastern

part, seismic sounding revealed a trough in the ocean floor, the axis of which averaged 1100 meters below sea level. This trough was still evident when crossed by the Ellsworth traverse party for the last time at 82°S, some 300 miles inland from the front of the shelf.

These findings reopened the question of whether the Antarctic continent is divided by a down-warped, ice-filled depression connecting the Ross and Weddell Seas.

The airborne traverse followed a path at right angles to the hypothetical trough. Traveling in a Navy aircraft, the three-man scientific team made seven landings along meridian 130°W. They covered some 400 miles between the Harold Byrd Mountains and the Executive Committee Range. (See Fig. 7.)

Geographic positions were determined by solar navigation, surface elevations by altimetry, and ice thicknesses by seismic sounding. Gravity observations were made throughout, to indicate ice thickness in the event areas were encountered in which no suitable seismic reflections could be obtained, and to provide information on the type of underlying rock. Shallow pit studies and coring determined the mean annual temperature and snow accumulation, and magnetic declinations were measured. Three hours' work was required at each station.

The seismic program at each station consisted of a vertical sounding for ice thickness, and of small explosions at each end of a 330-meter cable on the ice surface; the cable contained 12 geophones, equally spaced, to determine the average seismic-

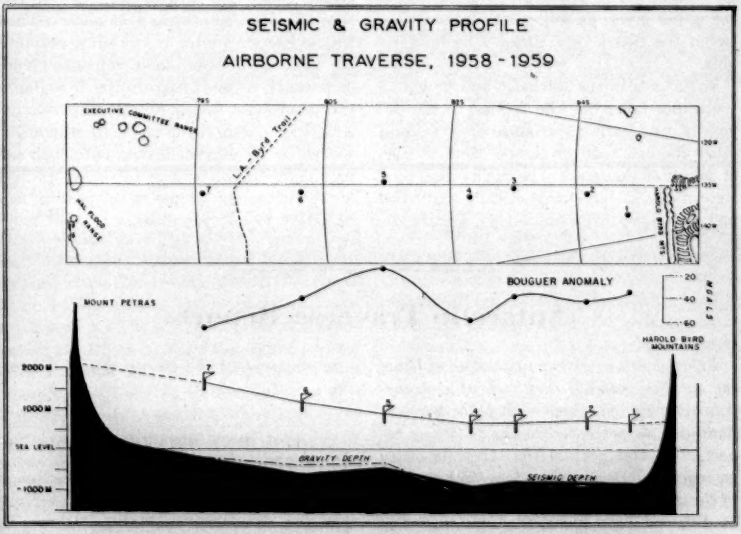

Fig. 7. *Seismic and Gravity Profile Obtained on Airborne Traverse. Ice is shown to be grounded at all seven stations between the mountain ranges, lending support, in this region, to the thesis of a connection between the Ross and Weddell Seas in the form of a down-warped, ice-filled trough.*

wave velocity for the ice column. Good reflections were obtained at five stations; those at the other two were usable but of poorer quality, perhaps because of nearness to crevassed areas.

Figure 7 contains a profile presenting the results of this seismic program. Since the ice is shown to be grounded at all seven stations between the mountain ranges at either end of the line, there appears to be virtually no possibility of water interchange between the Ross and Weddell Seas. However, the profile does appear to support the thesis of a down-warped, ice-filled trough connecting the two seas. Nevertheless, additional data, especially on the area to the east, are needed.

Related Results

Some further light is thrown on the trough problem by data so far available from the Marie Byrd Land oversnow traverse of 1958–59, which was in the field at the same time as the airlifted group. (This traverse is discussed in more detail in Part II, where it is referred to as the Horlick Traverse.) It traveled a triangular path: leg A, from Byrd Station across the hypothetical trough region to the foot of the Harold Byrd Mountains; leg B, eastward roughly paralleling the great trans-Antarctic range; and leg C, back to Byrd Station, once again crossing the trough region.

Leg A produced results similar to those found by the airborne party along 130°W —grounded ice resting on a rock surface below sea level. Over much of leg B the buried rock surface was found to be above sea level; this is not surprising since it paralleled the mountains to the south of the axis of the hypothetical downwarp. On the southern half of leg C the buried rock surface was found to be above sea level, with the important exception of a 40-mile gap where the rock descended to 1000 meters below sea level. Since the rock surface below Byrd Station is known to lie 1000 meters below sea level, any trough must pass through or near the Byrd Station area, or through the 40-mile gap found on leg C. (An earlier figure of about 1500 meters, or 5000 feet, for depth of the rock surface in the Byrd Station area has been corrected to 1000 meters, based on additional data and computations.)

To help determine whether such a trough actually extends across the continent or whether it is broken by a land bridge under the ice between the South Pole region and the Palmer Peninsula Mountains bordering the Weddell Sea, an airborne traverse along the 88°W meridian between the Horlick and Sentinel Mountains has been proposed for the coming Antarctic field season. This area is considered the most likely for such a connection because of its isolated nunataks and high snow surface.

II. MARIE BYRD LAND TRAVERSES

Study has been carried out to date on the results of three oversnow traverses in Marie Byrd Land. The first (Fig. 8) followed the pre-established trail from Little America Station to Byrd Station during the month of February, 1957. The second, or Sentinel, traverse proceeded clockwise around a loop to the northeast of Byrd Station between November 19, 1957, and February 19, 1958. The third (Horlick) traverse lasted from November 1, 1958, to January 20, 1959, and covered, in a counter-clockwise direction, a loop south of Byrd Station.

On all traverses, seismic reflection shooting was carried out at intervals of about 30 nautical miles, with gravimetric, magnetic, and altimetric measurements every three miles. Reflection shooting was supplemented by a large number of short refraction measurements in which the variations of seismic-wave velocities in the upper 50 meters of firn were studied, and by eight long refraction profiles which produced information concerning velocities throughout the icecap and in the rock beneath.

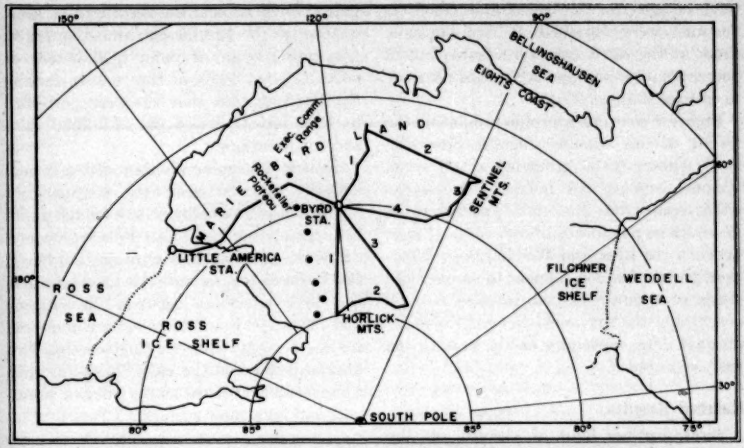

Fig. 8. *Routes of the Three Oversnow Traverses in Marie Byrd Land. The first, in February, 1957, was from Little America Station to Byrd Station. Between November 19, 1957, and February 19, 1958, a four-leg traverse was made in a clockwise direction from Byrd Station to the Sentinel Mountains and back. A third traverse was made from November 1, 1958, to January 20, 1959, taking a counter-clockwise triangular path south of Byrd Station into the Horlick Mountains. Dots are airborne-traverse stations.*

Basal Ice Layer

On a number of reflection records exhibiting a minimum of interference from prolonged surface noise, reflected energy was received several tenths of a second before the main echo from the ice-rock interface. This early reflection was particularly noticeable on records obtained throughout the second leg of the Sentinel Traverse. By combining results of vertical and wide-angle reflections it was possible to determine the existence of a layer at the base of the ice, having a thickness of about 300 meters, in which the primary wave velocity is approximately 3600 m/sec, as compared with 3850 m/sec in the icecap proper.

A comparison of the amplitudes of the early and main reflections shows that the density of the layer must be very close, if not equal, to that of ice. G. de Q. Robin has shown in laboratory experiments that near the melting point the wave velocity in ice decreases very rapidly. It is therefore tentatively concluded that the layer at the base of the icecap consists of ice at the pressure melting point, perhaps either a zone of stagnant ice or a zone of flow. Further study of this layer during future traverses is planned.

Cross-Sections to Bottom

Seismic reflection and gravity results have been combined to draw cross sections of the icecap along the paths shown in Figure 9 for the Little America—Byrd Station Traverse and for the Sentinel Traverse, and, in Figure 10, for the Horlick Traverse. The dashed line in Figure 10 shows an approximate position of sea level relative to the rock surface if the ice were removed and allowance made for "isostatic rebound." (This adjusted position of sea level is here referred to as reduced sea level.)

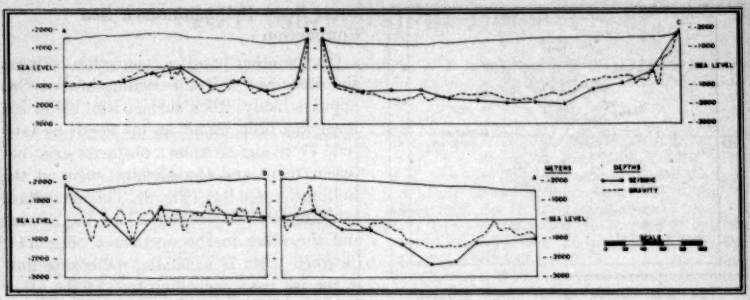

Fig. 9. *Seismic and Gravity Depth Sections Obtained on Byrd-Sentinel Traverses. (Scale in nautical miles.) From the Ross Ice Shelf to the end of the first leg of the Sentinel Traverse, the rock surface is as shown in Section A-B, moderately rough with all but a few peaks well below sea level. The third leg of the Sentinel Traverse, Section C-D, reveals a very rough, mountainous rock surface largely above sea level. The second and fourth legs of this traverse, Sections B-C and D-A, show a deep, smooth, basin-like surface.*

From the Ross Ice Shelf—Rockefeller Plateau boundary to the ends of the first legs of the Sentinel and Horlick Traverses, the picture is generally the same. The rock surface is moderately rough with all but a few peaks well below sea level. The eastern parts of both the Sentinel and Horlick Traverses (leg 3 of the former, leg 2 and the first half of leg 3 of the latter) exhibit a very rough, mountainous rock surface largely above sea level. In intervening areas on the Sentinel Traverse (legs 2 and 4) a deep, smooth, basin-like surface is seen, separated from the mountainous area by a transition zone more or less at reduced sea level.

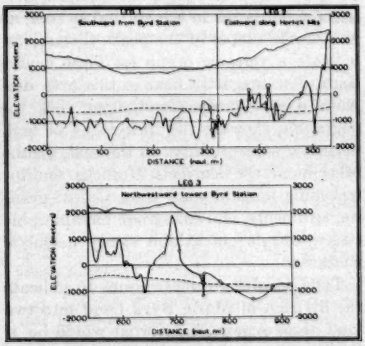

Fig. 10. *Cross Sections of the Icecap and its Underlying Rock Based on Seismic and Gravity Readings Taken on the Horlick Traverse. The dashed line shows sea level as it would be if the ice were removed and allowance made for isostatic rebound.*

Figure 11 is a map of Marie Byrd Land on which are shown contours of the ice surface and a general division into zones depending upon the nature of the rock floor. To the west is an island zone in which the rock level is generally below reduced sea level but with scattered points protruding above. East of this in the northern part of the area is the basin zone, typified by a smooth rock surface beneath the ice. To the west is the high, rugged mountain zone—from the Ross Ice Shelf to the Sentinel Mountains. Between the basin and mountain zones is a transition zone in which the rock surface is more or less flat and at a reduced sea level. The distinction between the island, basin, and transition zones is lost farther south.

The continuity of the mountain zone deserves examination if a decision is to be made on the existence or absence of a trough

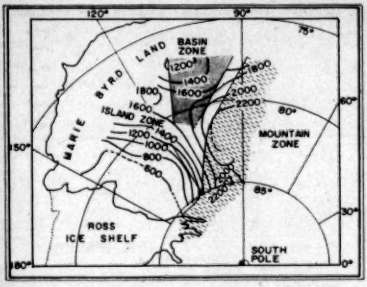

Fig. 11. *Marie Byrd Land Divided into Three Zones According to the Nature of the Rock Floor. In the island zone to the west, rock level is generally below "reduced" sea level, i.e., the adjusted sea level if ice were removed and allowance made for isostatic rebound. To the north is a basin zone, with a smooth rock surface well below reduced sea level. The mountain zone to the east has a high and rugged rock surface beneath the ice. The contours (in meters) show the topography of the ice surface.*

connecting the Ross and Weddell Seas. North of 81°S the Sentinel Mountains and their extension above and below the ice surface form a continuous barrier. In the south, the Horlick Mountains and the sub-ice topography protrude above reduced sea level as far north as 82½°S, with the exception of the narrow deep spot shown on the third leg of the Horlick Traverse at 83½°S.

Thus, it appears that there is no *broad* trough south of 82½°S connecting the Ross and Weddell Seas. Between 81°S and 82½°S there is no north-south coverage far enough east to bear on the problem. More information must therefore be obtained in the vicinity of 90°W before the possibility of a below-sea-level connection can be eliminated.

Ross Sea—Bellingshausen Sea Connection

On the other hand, a connection between the Ross Sea and the Bellingshausen Sea appears likely. Rock surface well below sea level has been found as far north as latitude 77°S, and no known obstacles exist between there and the Eights Coast on the Bellingshausen Sea (Fig. 8). The ice surface exhibits two definite highs, one in the east and the other in the northwest (Fig. 11). Between them is a saddle, indicating flow of the ice from each high toward the other and off to the southwest and north. The profile of leg 1 in Figure 10 shows that the low ice-surface elevations south of Byrd Station are not a reflection of sub-ice topography, and must therefore be attributed to the pattern of ice flow. Thus, the surface contours suggest that there were once two separate ice caps, one centered on the area of the Executive Committee Range and the other along the Sentinel—Horlick axis, and that these two caps converged on the water-covered zone between them.

Geological and magnetic data show the mountains in the two areas to be entirely different in character. Rock samples collected from peaks in the northwest area, as well as the shapes of the peaks themselves, indicate a volcanic origin for these mountains. The magnetic field in this area displays a strong dependence upon rock topography, showing the rock to be of high magnetic susceptibility. In the east, on the other hand, the Sentinels, Horlicks, and intervening nunataks are composed of granite, sediments, and low-grade metamorphic rocks, and do not exhibit strong magnetic character.

Thus, present evidence seems to indicate the division of Marie Byrd Land into two land areas separated by what would be, if the ice were removed, an area of open water running from the Ross to the Bellingshausen Sea.

IGY Bibliographic Notes

This is the twelfth of a series of bibliographic notes on IGY programs and findings. The references are selected largely from an IGY bibliography under preparation in the Science and Technology Division of the Library of Congress.

IGY Bibliography

The first volume of the International Geophysical Year Bibliography is available from the Publishing and Printing Office, National Academy of Sciences, 2101 Constitution Avenue, N. W., Washington 25, D. C. Price $1.00, postage prepaid. The 64-page volume contains 704 references.

The Bibliography is being compiled at the Library of Congress and is a joint project of the Library, the Academy, and the National Science Foundation.

J. Ashbrook, G. F. Schilling, and T. E. Sterne: Glossary of Astronomical Terms for the Description of Satellite Orbits. Smithsonian Contributions to *Astrophysics*. Vol. 2, no. 10. 1958. Pp. 211-214.

D. R. Barber: Origin of Upper-Atmosphere Lithium Atoms Responsible for the New Twilight Airglow at 6708A. *Nature*. Vol. 183. Feb. 7, 1959. P. 384.

Leon Blitzer: Earth Oblateness in Terms of Satellite Orbital Periods. *Science*. Vol. 129. Feb. 6, 1959. Pp. 329-330. Diagr.

C. H. Bosanquet: Change of Inclination of a Satellite Orbit. *Nature*. Vol. 182, no. 4648. Nov. 29, 1958. P. 1533.

S. A. Bowhill: The Faraday-Rotation of a Satellite Radio Signal. *Journal of Atmospheric and Terrestrial Physics*. Vol. 13, nos. 1 and 2. Dec. 1958. Pp. 175-176. Diagr.

K. L. Bowles: Observation of Vertical-Incidence Scatter from the Ionosphere at 41 mc/sec. *Physical Review Letters*. Vol. 1. Dec. 15, 1958. Pp. 454-455. Illus.

R. L. F. Boyd: Space Research. *Nature*. Vol. 183. Feb. 7, 1959. Pp. 361-364.

Chapman, Sydney: The Earth and Its Environment. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 137-141.

Evert Clark: Pioneer Indicates Restricted Radiation. *Aviation Week*. Vol. 69, no. 16. Oct. 20, 1958. Pp. 30-33. Illus., diagr.

F. F. Evison, C. E. Ingham, and R. H. Orr: Thickness of the Earth's Crust in Antarctica. *Nature*. Vol. 183. Jan. 31, 1959. Pp. 306-308. Diagr., map.

Edwin Flowers: Inside Antarctica No. 2—Amundsen-Scott Station. *Weatherwise*. Vol. 11. Oct. 1958. Pp. 166-171. Illus., map.

O. K. Garriott and O. G. Villard, Jr.: Antipodal Reception of Sputnik III. *Proceedings of the IRE*. Vol. 46, no. 12. Dec. 1958. P. 1950. Illus.

M. J. Hendrie: The Photographic Observation of Artificial Satellites. *Spaceflight*. Vol. 1, no. 8. July 1958. Pp. 267-274. Illus., diagr.

H. A. Hess: Registrierung des Sputnik II Auf 40.002 KHZ. *NTZ*. Vol. 11, no. 7. July 1958. Pp. 347-348. Illus., diagr.

N. E. Howard: *Handbook for Observing the Satellites*. New York, Thomas Y. Crowell, 1958. P. 136. Illus., diagr., maps.

International Geophysical Year. *WMO Bulletin*. Vol. 7. Oct. 1958. Pp. 154-156. Illus.

V. A. Kotel'nikov, V. M. Dubrovin, V. A. Morozov, O. N. Rzhiga, and A. M. Shakhovskoi: Determination of Satellite Orbit Parameters With the Use of the Doppler Effect. *Physics Express*. Vol. 1, no. 3. Sept. 1958. P. 33.

IGY Special Studies in Meterology. *Weatherwise*. Vol. 12, no. 2. April 1959. Pp. 67-72. Diagr., maps.

Jacchia, Luigia G.: Two Atmospheric Effects in the Orbital Acceleration of Artificial Satellites. *Nature*. Vol. 183. Feb. 21, 1959. Pp. 526-527. Diagr.

Krassovsky, V. I.: Exploration of the Upper Atmosphere with the Help of the Third Soviet Sputnik. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 289-296. Illus., diagr.

Marshall Melin: Man's Farthest Step into Space. *Sky and Telescope*. Special Supplement. Vol. 18, no. 1. Nov. 1958. Pp. 1-8. Illus., diagr.

R. H. Merson, D. G. King-Hele, and R. N. A. Plimmer: Changes in the Inclination of Satellite Orbits to the Equator. *Nature*. Vol. 183. Jan. 24, 1959. Pp. 239-240. Diagr.

W. B. Moreland: Inside Antarctica No. 3—The Weather Central at Little America. *Weatherwise*. Vol. 11. Dec. 1958. Pp. 196-200. Illus., maps.

Robert R. Newton: Lifetime of Artificial Satellites. *Jet Propulsion*. Vol. 28, no. 5. May 1958. Pp. 331-333.

Nicolet, Marcel: The Constitution and Composition of the Upper Atmosphere. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 142-147.

Yngve Öhman: Solar Flares and Surges Observed at the Swedish Astrophysical Station in Anacapri in the Year 1957. *Stockholm Observatoriums Annaler*. Vol. 20, no. 7. 1958. Pp. 1-38. Illus., diagr.

Glauco Partel: Il "Pioneer" Primo Concerto Tentativo Verso la Luna. *Rivista Aeronautica*. Vol. 34, no. 11. Nov. 1958. Pp. 1649-1656. Illus.

Routledge, N. A.: Russian Contributions to the International Geophysical Year. *Nature*. Vol. 183, No. 4668. April 18, 1959. Pp. 1087-1088.

G. F. Schilling and T. E. Sterne: Densities and

Temperatures of the Upper Atmosphere Inferred from Satellite Observations. *Journal of Geophysical Research*. Vol. 64. Jan. 1959. Pp. 1-4. Diagr.

C. A. Schroeder, E. J. Habib, and W. R. Silvester: Time Standard. *Naval Research Laboratory Report No. 5227*. Oct. 22, 1958. P. 44. Illus., diagr. (Project Vanguard Report No. 36; Minitrack Report No. 8; PB Report No. 151169).

T. J. Seed: V.H.F. Observations on the Aurora Australis. *Journal of Geophysical Research*. Vol. 63. Sept. 1958. Pp. 517–526. Illus., diagr.

Yoshida Sekiko and Masami Wada: Storm-Time Increase of Cosmic-Ray Intensity. *Nature*. Vol. 183. Feb. 7, 1959. Pp. 381–383. Diagr.

R. L. Smith-Rose: Electron Density Profiles in the Ionosphere During the IGY. *Journal of Geophysical Research*. Vol. 63. Sept. 1958. Pp. 570–572.

Strahlungsmessungen Durch Explorer IV: *Raketentechnik und Raumfahrtforschung*. Vol. 2, no. 4. Oct. 1958. Pp. 131–132. Diagr.

Swedish-Finnish-Swiss International Year Expedition to Nordaustlandet, 1957–58, and Swedish Expedition to Nordaustlandet, 1958–59. Season 1957–58. *Polar Record*. Vol. 9. Jan. 1959. Pp. 338–339.

M. C. Thompson, Jr., and D. M. Waters: Comparison of Phase Difference and Doppler Shift Measurements for Studying Ionospheric Fine Structure Using Earth Satellites. *Proceedings of the IRE*. Vol. 46, no. 12. Dec. 1958. P. 1960. Diagr.

Unwin, R. S.: The Geometry of Auroral Ionization. *Journal of Geophysical Research*. Vol. 63. Sept. 1958. Pp. 501–506. Illus., diagr.

Venkiteshwaran, S. P.: Atmospheric Electricity Observations in India during the IGY—Radiosonde Techniques for Measuring Potential Gradient and Conductivity. *Journal of Scientific and Industrial Research*. Vol. 17A, no. 12. Dec. 1958. Pp. 24–32. Illus., diagr.

E. Woyk (E. Chvojková): Investigations of the Ionosphere Using Signals from the Earth Satellites. *Nature*. Vol. 182, no. 4646. Nov. 15, 1958. Pp. 1362-1363. Diagr.

Vol. 40, No. 3 TRANSACTIONS, AMERICAN GEOPHYSICAL UNION September 1959

NATIONAL ACADEMY OF SCIENCES

Number 26 • August 1959

IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation-1959 as related primarily to United States programs.

Unusual Radio-Signal Enhancement in the Far East

The following report is based on material supplied by J. W. Finney, E. K. Smith, L. H. Tveten, and J. M. Watts, of the Central Radio Propagation Laboratory, National Bureau of Standards' Boulder Laboratories, and Ross Bateman, of Page Communications Engineers, Inc. A more detailed account was published in the Journal of Geophysical Research, *April 1959.*

Radio propagation studies in the eastern Pacific just prior to and during the IGY revealed an anomalous increase in the intensity of very-high-frequency (VHF) radio signals over several propagation paths between the Philippines and Okinawa. The enhancement occurred during the evening, beginning about two hours after sunset and lasting until about midnight. It was particularly strong during the autumnal equinox.

Signals with frequencies above about 30 megacycles per second are not generally reflected by the ionosphere, but penetrate it completely and continue into space. Under certain special conditions, however, generally by "scatter" and by "sporadic-E" propagation, ionospheric transmission may be effected at frequencies up to about 100 mc/sec. Scattering results from irregularity of surfaces of equal ionization density in the ionosphere or from discontinuity of the electron density at some level; generally, such turbulent conditions result in partial reflection of the original wave energy up to frequencies considerably higher than normal. Sporadic E is probably the result of reflections from clouds or patches of unusually high ionization in the E region of the ionosphere.

Propagation of VHF radio signals along paths between the Philippines and Okinawa normally takes place by scatter in the lower ionosphere or, occasionally, by sporadic E. The IGY equipment that monitored the enhanced signals was originally set up by the Central Radio Propagation Laboratory (CRPL) to measure sporadic-E propagation. However, the abnormal signal enhancement observed along these paths was often as much as 30–40 decibels above normal at a frequency of about 50 mc/sec, and 40–50 db above normal at about 36 mc/sec.

The experiments described were made with the cooperation of the Voice of America, the US Army IGY Support Group, and the Philippine IGY Committee.

Observational Circuits

The anomalous enhancement was first measured over an experimental circuit at 36.4 mc/sec between Poro Point, Philippine Islands, and Sobe, Okinawa (1329 kilometers), operated from May 1956 to

May 1957. The IGY circuit designed to measure sporadic E began operating in September 1957 at 49.84 mc/sec over a nearly identical, 1347-kilometer circuit between Poro Point, P. I., and Onna, Okinawa.

During the May 1956–1957 period of operation at 36.4 mc/sec, peaks in the number of occurrences of the evening enhancement were reached during both the spring and fall equinoctial periods. In the following year, however, at 49.84 mc/sec, only the fall peak was observed; during the 1957 spring equinox, in fact, there appeared to be a minimum in the number of occurrences.

Figure 1 is a graph showing monthly medians of hourly median signal intensities for both propagation paths during the months of October and November 1956 and 1957. It can be seen that in both years October was a month in which the anomaly occurred very often and November was a month of few occurrences.

Based on the observations at 50 mc/sec and below, it has been estimated that the intensity of the anomalous signal decreases by about one decibel for each megacycle of frequency increase. If this estimate is also valid for frequencies above 50 mc/sec, it may be possible to distinguish the unusual enhancement to frequencies as high as 80–90 mc/sec.

An additional propagation path was set up between Okinawa and the Manila area to observe the behavior of the anomaly. Southbound transmissions were at 36.4 mc/sec. At each terminal, dipole antennas were

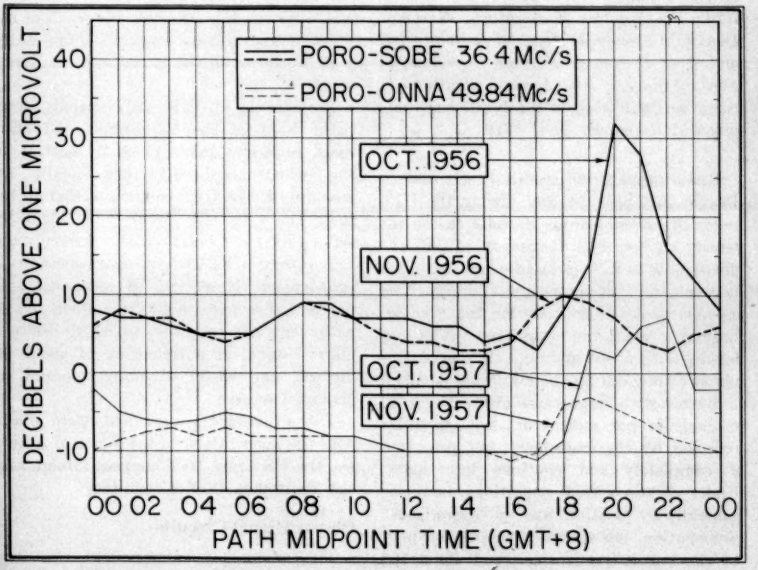

FIG. 1. *Curves of Monthly Medians of Hourly Median Signal Intensities Over the Two Philippines-Okinawa Propagation Paths. The evening-hour intensity increase is clearly shown, as well as the tendency for the enhancement to occur frequently in October and relatively infrequently in November.*

alternated at half-hour intervals with corner-reflector antennas. For the northbound transmissions, at 40.2 mc/sec, antennas beamed on the great-circle path between the two points were alternated at half-hour intervals with symmetrical split-beam antennas at each end. The split-beam antennas had a radiation pattern with beam maxima about 8° on each side of the great-circle path, and a "null" along the great-circle path itself.

It appears that most of the time during periods of abnormally enhanced propagation, the signals arrive from directions predominantly on one side or the other of the great-circle bearing. Occasionally, and particularly during the later stages of the periods of enhancement, extremely strong signals were received along the great-circle path. During these times, the intensity of signals observed with the split-beam antennas was characteristically lower than the intensity of signals received with the "normal" beam.

Pulse Experiments

Pulse measurements were made over the Poro Point-Onna path in September 1958. In such experiments, short, pulsed signals are sent into the ionosphere and the time between transmission and reception is measured. Assuming that radio signals travel at the speed of light, the height of the reflecting layer can then be computed.

For the pulse experiment, a peak pulse power of two kilowatts was used and independent time standards were employed to control the pulse repetition rate (100/sec) at the transmitter and the oscilloscope sweep rate at the receiver. Records were obtained for four nights. The normal E-region echo was shown at the bottom of each record so that the time delay of the abnormal echo could be compared to it.

The records for both September 22 and 23, 1958, show an abrupt start of the anomalous signal at a time delay of about 1200 microseconds behind the E-region pulse. The commencement time for the anomalous signal was 1924 (local time) on September 22 and 1911 on September 23. On the 22nd, the delay time had decreased to 500 microseconds by 2300 and on the 23rd it fell to 600 at 2130, after which the E-region echo dropped out entirely.

A delay of 400 microseconds relative to the E-region echo corresponds geometrically to a reflection height of about 300 kilometers at the mid-point of the great-circle path; a delay of 1100 microseconds corresponds to a height of about 500 kilometers. Small lateral deviations from the great-circle path would not materially affect these figures. The transmitted pulse —50 microseconds long—was broadened to approximately 1500 microseconds in the earlier hours; this value decreased to less than 500 microseconds in the later stages of the enhanced propagation.

Comparisons with Other Stations

The periods of anomalous propagation over the Poro Point-to-Onna path during September 1957 were compared with ionospheric data from the ionosphere stations at Baguio, P. I., and on Okinawa. No association could be found between the anomaly and E-region effects. The abnormal propagation periods did, however, appear to correspond to periods of spread-F propagation at Baguio and of high F2 critical frequencies at Okinawa, where spread F is comparatively rare. (Spread echoes are scattered through a frequency range of several megacycles instead of remaining at the transmission frequency. Spread-F scattering occurs in the F region of the ionosphere. Critical frequencies are the maximum frequencies reflected by the individual ionospheric layers. Critical frequencies vary with ionosphere conditions.)

Values of the F2 critical frequency observed at the Okinawa ionosphere station in the evening hours are among the highest

in the world. The F2 maximum usable frequency (MUF) for the Poro Point-Onna propagation path is often as high as 35 mc/sec, and may have reached 40 mc/sec on at least one occasion. It might be argued, therefore, that the unusually intense propagation in the 35–40 mc/sec range derives from some peculiarity related to the F2 critical frequency. However, the fact that this anomaly has also been observed at approximately 50 mc/sec makes this hypothesis untenable.

Recent measurements during the enhancement indicate a fading rate on the order of 5 cycles/sec at a frequency of 50 mc/sec. This is approximately the same as the fading rate for normal scatter fading; the fading rate for periods of sporadic-E transmission, however, is usually much lower.

There is some evidence of a small negative correlation with magnetic activity. At the mid-points of the Philippines-to-Okinawa propagation paths, the magnetic dip of the ionosphere is about 28°. A circuit from Panama to Guayaquil, Ecuador, operated at 50 mc/sec by the National Bureau of Standards in the latter part of the IGY, although having roughly the same magnetic configuration as the Philippines-Okinawa paths, has shown few occurrences of the abnormal signal enhancement. Some observations of what appears to be the same anomaly have been made on winter nights at 50 mc/sec over a path between Panama and the US Naval Base at Guantanamo Bay, Cuba. This path has a magnetic inclination of 44° at mid-point.

Conclusions

The investigators believe that results of the experiments described indicate that the anomalously intense signal is propagated via the F region of the ionosphere and is associated with low-latitude spread F, as observed with ionosphere sounders. The relatively well-defined lower edge of the anomalous echo (usually present in visual records of scattered signals) can be interpreted in either of two ways: (1) It may represent the limiting geometric distance to the lowest stratum of ionized "blobs" in the F region; or (2) it may be the closest approach of the locus of the specular, or reflecting, condition in the F region that permits optimum scattering from blobs of ionization aligned parallel with the earth's magnetic field. The investigators consider the latter interpretation more probable.

Aurora Observations at the South Pole

This report is based on material prepared by C. W. Gartlein, B. Nack, and G. Sprague of the IGY Visual Auroral Data Center, Cornell University.

Three main conclusions have been drawn from aurora observations at the South Pole and other US-IGY Antarctic stations. They concern the location of the auroral zone; the daily shift of the position of the zone, and the effects of twilight on auroral reporting.

The results of visual auroral observations at US-IGY South Pole Station have a special interest because of the relatively fixed relation between the observers and the sun. In particular, the sun maintains an almost constant depression below the horizon for forty days starting at the first of June. Hence, auroral observations for

this time and place are not complicated by the effect of twilight on visibility.

Auroral Distribution

The South Pole observations show that, within the region circled by the zone of maximum auroral frequency (see Fig. 2), there is a definite increase in the number of overhead auroras with distance from the geomagnetic pole. Taking into account similar data from other US-IGY stations, it appears that the southern region of maximum aurora frequency is outside (north of) NAF McMurdo and Little America, Byrd, Wilkes, and the South Pole Stations, but inside Ellsworth Station.

Based on South Pole and other auroral observations, together with theoretical calculations based on the earth's magnetic field, the authors have determined the approximate positions of three major boundaries of auroral activity. These boundaries are shown in Fig. 2.

Line A represents the outermost edge of the biggest auroras seen during the IGY. This boundary passes between the two main islands of New Zealand.

Line B is the outermost edge of the region in which the greatest number of au-

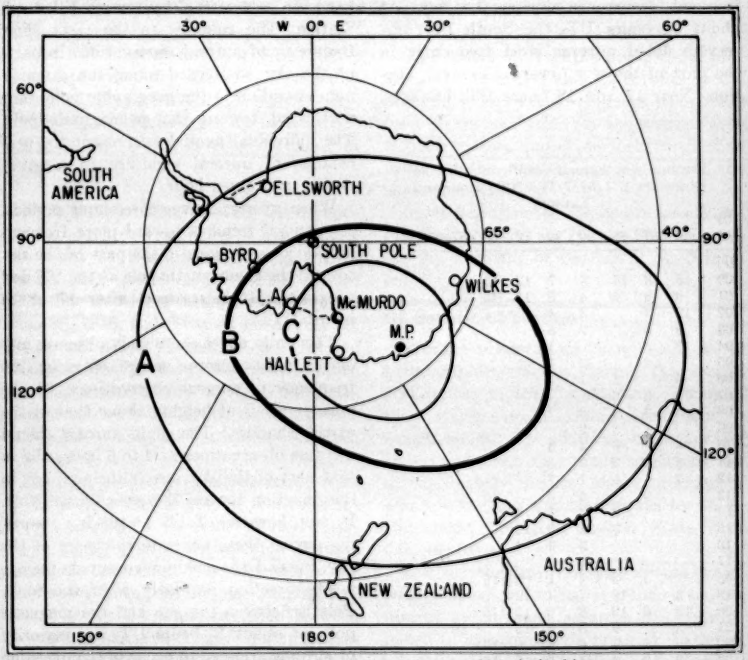

FIG. 2. *Aurora Australis. Line A represents the outermost edge of the biggest auroras seen from the South Pole and other stations during the IGY. Line B is the outer edge of the region where the greatest number of auroras are seen. Line C bounds a zone inside which "irregular" auroras occur. LA identifies Little America Station, MP the magnetic pole.*

roras are seen, and therefore is an approximation of the southern auroral zone.

Auroras occurring inside C are somewhat different from those reported outside C in that arc forms and flames are not seen. Instead, the display consists of rays and surfaces; both are distributed in patches and the small individual features are of short duration, giving a flickering appearance rather than regular pulsations.

Daily Motion

A noteworthy feature of the auroral distribution is a shift in the latitude of most frequent occurrence during the day. At about 01 hours UT, the South Pole observers noted auroras most frequently in the part of the sky toward Ellsworth Station. Near 17 and 18 hours UT, however, the concentration had shifted to the opposite part of the sky, or toward the geomagnetic pole. (See *Bulletin No. 12* for method of calculating ground point over which aurora occurs.)

TABLE 1
Frequency of Auroras Seen by South Pole Observers, 6/1/57–7/14/57, By Hour and Latitude

°S Lat.	86	87	88	89	90	89	88	87→(GMP)
UT								
00	15	18	15	5	7	12	15	
01	9	9	9	4	3	12	15	50
02	12	3		3	4			
03	9	6		2	5			
04	3				1			
05		6		2	1			
06	6		3	1	1			
07		3	6					
08	3	3	6	2	2			
09			3	2				
10	6		6	4	3			
11	3	12	3	2	5			
12	3			1	7			
13		9		5	6		15	
14			3	3	1	4		
15			3	1	3	12		
16				3	3	4		
17				1	3			
18		6	6	1	1	8	15	
19	3	9	12	7	4	12		
20	12	6	12	8	9	12	15	
21	3		9	5	5	12		50
22	12	18	6	6	6	8	15	
23	6	6	3	4	6	12	15	

Note: The unit used is the number of forms reported divided by the number of clear observation hours.

Table 1 indicates the frequency of auroras seen by South Pole observers at different hours of the day in different parts of the sky along their geomagnetic meridian (i.e., the meridian from the geomagnetic pole that passes through the zenith point above the station). The parts of the sky are identified in term of degrees of geographic latitude along this geomagnetic meridian. The tabulation starts at the left, from the part of the sky toward Ellsworth Station. The columns to the right show frequency of auroral observations in parts of the sky southward along the geomagnetic meridian to the geographic pole, then northward toward the geomagnetic pole. The individual numbers represent the percentage of auroral sightings in a given region in a given hour.

When averaged over three-hour periods, the general trend is toward more frequent auroral observations in the part of the sky toward the geomagnetic pole as the UT day progresses. It is reversed after 17 or 18 hours UT.

This daily effect completely obscures any effect sunlit auroras might have on the frequency of auroral observations. (Sunlit auroras occur at heights above that of the earth's shadow.) The sunlit auroras should increase observations at 4 to 6 hours UT in that part of the sky nearer the sun, i.e., in the direction toward the geomagnetic pole. In fact, however, Table 1 records no auroras during these hours in this part of the sky. Instead, the maximum occurs in the opposite direction. Similarly, when the South Pole is between the sun and the magnetic pole, at about 16 hours UT, the majority of auroras are seen to occur in the direction opposite to the sun.

The daily effect is probably due to the apparent motion of the earth's magnetic

field with respect to the South Pole and the sun. This implies a seasonal effect.

Twilight Effect

The aurora sightings per hour are fairly constant until the sun climbs to a point about 18° below the South Pole's horizon. Then, sightings decline with the sun's continued rise toward the horizon. This twilight effect is probably physiological, i.e., the observers become unable to distinguish faint auroras against a brighter sky, rather than a physical effect in which sunlight in some way desensitizes the atmosphere to auroras. It is, therefore, advisable to treat with reserve data obtained when the solar angle of depression is less than 18°.

Second Brown Bear Cruise

The following material is based on a report submitted by Richard H. Fleming and staff, Department of Oceanography, University of Washington. An earlier IGY cruise of the Brown Bear *is described in* Bulletin No. 9.

During the summer of 1958, the oceanographic research vessel *Brown Bear*, of the University of Washington, carried out its second IGY cruise (*Brown Bear* Cruise 199). The ship left Seattle, Washington, on June 30, 1958, and returned on August 20. The cruise track covered an area of the Pacific generally west of the United States, reaching as far as 146°40′W, as far south as approximately 32°N, and including stops at San Diego and San Francisco, California (see Fig. 3).

The major objectives of the cruise were (a) to reoccupy hydrographic stations originally occupied by the research vessel *Carnegie*, in 1929, to determine what changes may have occurred in the properties of the deep water during the 29-year interval, and (b) to study the transition zone between Sub-Arctic and Sub-Tropic Water masses in the Northeast Pacific. In addition, a comprehensive program of oceanographic sampling was carried out along the cruise track.

This report outlines the observation program on the cruise and gives some of the preliminary results. It appears from these preliminary analyses that the warmer subtropical waters moved farther north than usual in the eastern Pacific during the summer of 1958.

Chief Scientist for the cruise was Maurice Rattray, Jr.; the *Brown Bear* was under the command of Captain F. W. Princehouse.

Observation Program

Routine observations were made at 42 hydrographic stations during the second IGY cruise of the *Brown Bear*. Three of these stations were inshore, contiguous to Puget Sound. In addition, a mid-water trawl was used to collect specimens for marine biology studies, and a program of albacore tagging was undertaken by R. L. Ridenhour, biologist, Oregon State Fish Commission.

Routine chemical analyses of sea water were carried out. The suspended matter filtered out of some samples will be subjected to spectrographic analyses to determine inorganic composition and distribution of trace elements (elements other than the eight relatively abundant rock-formers —O, Si, Al, Fe, Ca, Na, K, and Mg).

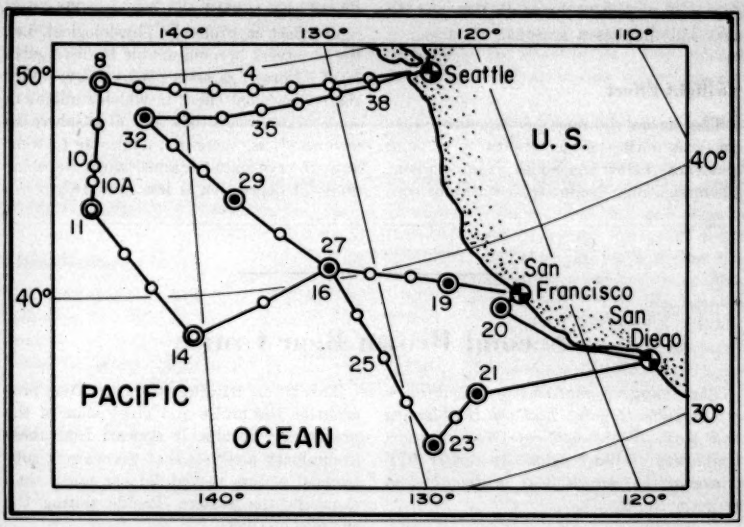

FIG. 3. *Track of Second IGY Cruise of* Brown Bear. *Single small circles represent standard hydrographic stations; double circles represent deep stations, with black dots signifying those previously occupied by the research vessel* Carnegie *(1929).*

Water samples for C-14 analysis were obtained from a depth of 100 meters above the bottom at 11 stations and from the minimum oxygen layer at 5 stations. (Some oceanographers believe that oxygen distribution in the ocean is closely related to water motion, and that layers of minimum oxygen content represent layers of minimum horizontal movement.)

Bottom cores were obtained along the cruise track to determine carbonate distribution and the magnesium-to-calcium ratio in carbonate bottom sediments.

Temperature-salinity curves and vertical sections of density were compiled for each hydrographic station occupied. Geopotential topographies of various pressure levels were also compiled. (Geopotential topography is determined by computing the varying values of density at any given depth. The horizontal hydrostatic pressure gradient determined from the density variation balances the Coriolis force—the effect of the earth's rotation on moving bodies; hence, study of geopotential topography supplies information on the strength and direction of currents. The pressure of the water is described in terms of decibars—1 decibar [10^6 dynes/cm^2] represents very nearly the force exerted by a column of water 1 meter high.)

Physical Oceanography

Brown Bear Cruise 199 covered the eastern portion of the transition zone between the Sub-Arctic and Central Water masses, including the region where the Sub-Arctic Current splits into the Alaska and California Currents.

(Sub-Arctic Water is cold, with temperatures of 35°–39°F, and has low salinity at

the surface. North of about 45°N it flows generally eastward, part of it turning north as it approaches the West Coast of the US and part turning south at the coast to mix with Equatorial Water in the vicinity of 25° N. The Central Water is warmer and more saline than Sub-Arctic Water, and may originate approximately within the region 30°–40°N, 150°–160°E. Intermediate Water generally occurs below Central Water in the vicinity of 36°N and is characterized by a salinity minimum layer. Equatorial Water occurs mostly south of about 15°N and is warmer and generally more saline than the other water masses.)

Water Masses: Temperature-salinity diagrams for the Northeast Pacific during the summer of 1958 indicate that the distribution of water-mass types was generally similar to that reported by Canadian oceanographers for the summers of 1955-57, although warmer waters apparently moved farther north than usual.

In summer 1958, Sub-Arctic Water was centered along 45°N, entering the cruise area from the west as a band about 100 miles wide and increasing in width toward the east. At 130°W, this band of water stretched almost from 40° to 50°N (a width of nearly 600 miles), and evidently marked the boundary region where the eastward-flowing Sub-Arctic Current splits northward into the Alaska Current and southward into the California Current. Since the contours of geopotential topography spread apart (indicating weak pressure gradients) as they approached the coast (see Figs. 4 and 5), it appears that this wide band of Sub-Arctic Water had accumulated in a large area of weak currents off the coast.

Water below the halocline (zone of rapid increase of salinity, just beneath the surface layer) consisted of mixtures of Sub-Arctic Water with (a) Intermediate Water, (b) Central Water, or (c) Equatorial Water.

In the southeastern half of the cruise area, an appreciable amount of Equatorial Water was mixed with the Sub-Arctic Water at depths greater than 1100–1900 feet (depending upon location).

Between these levels and the halocline, the water consisted of a mixture of Sub-Arctic and Intermediate Waters. Intermediate Water made up a large proportion of the mixture generally in the southwestern part of the cruise area, and there seemed to be appreciable amounts in the central, east-central, and northeast part of the area. In the extreme southern and southwestern part of the cruise area, some Central Water could be found between the bottom of the halocline and the top of Intermediate Water layer.

Geopotential Topography: South of 50°N and west of 135°W, the geopotential topography of the surface relative to the 1200-decibar level (see Fig. 4) indicated a northeasterly flow of Sub-Arctic Water; east of 130°W, southeasterly flow is indicated in these latitudes. Water crossing the 50°N parallel in the region west of 130°W apparently continued northward into the Gulf of Alaska.

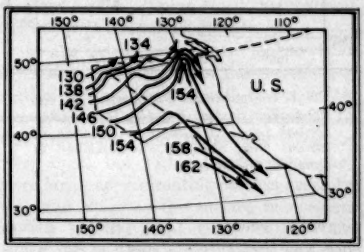

FIG. 4. *Geopotential Topography of the Sea Surface Relative to the 1200-decibar Level in the Cruise Area. Arrows show direction of current flow; contours are numbered in dynamic centimeters. (A dynamic centimeter represents the amount of work required to move a given mass through a vertical distance of one centimeter).*

The surface geopotential topography varies considerably from year to year in this region. The most notable features for 1958, compared to the previous three summers, were the existence of a northward component of flows over the whole western part of the area and concentration of the contours (indicating greater velocities) near 49°N, the highest such concentration during the period 1955–58.

The geopotential topography of the 200-decibar level relative to the 1200-decibar level had the same general features as that of the sea surface (see Fig. 5), but with

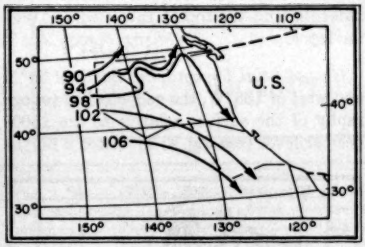

FIG. 5. *Geopotential Topography of the 200-decibar Surface Relative to the 1200-decibar Level. Arrows show direction of current flow; contours are numbered in dynamic centimeters.*

decreased velocities. The primary difference was that currents south of 45°N everywhere tended toward the south rather than toward the north, as they did at the surface west of 130°W.

Current Velocities: Throughout the cruise area, average currents were weak—about one mile per day—although locally currents at times reached 4–7 miles per day. The highest velocities were present near the coast of Washington State between 48°N and 50°N, where a portion of the northeast-flowing Sub-Arctic Current turns southeast along the coast. A region of rather weak currents, centered at about 45°N, 130°W, corresponded to a pressure ridge around which this stronger current flowed.

At the 200-decibar level, the strongest currents lay along a line from about 45°N, 146°W, to 49°N, 130°W, defining the front between the Sub-Arctic and Intermediate Water masses. Vertical sections of density verify the position of this front.

Temperatures: Unusually high surface temperatures and deeper-than-average thermoclines were evident in 1958. (The thermocline is a layer in which temperature decreases rapidly with depth.) The lowest surface temperature, 53.5°F, was measured in the northwest corner of the cruise area, with temperatures increasing toward the south and the east. The maximum temperature, 68.9°F, was observed at approximately 39°N, just north of Station 26 (Fig. 1).

The warmer-than-usual surface temperatures lay roughly in the region south of the subsurface front marking the transition between Sub-Arctic and Intermediate Waters and north of a surface front, 165–330 feet deep, at about 40°N near Station 13. This surface front also gave a southern limit to the currents turning northward along 130°W.

The vertical temperature structure was generally characterized by (a) a relatively uniform upper layer, (b) a thermocline layer, and (c) a layer in which the temperature gradient was small and decreased with depth. The maximum temperature gradient was generally near the top of the thermocline, at a depth of about 100 feet. Offshore, the thermocline appears to have been deeper in 1958 than the average for the period 1941-52; farther west it became shallower.

Rough estimates of the rate of change of surface temperatures were made in different parts of the cruise track on both outbound and return legs. They were as follows:

Areas	*°F/month*
Stations 16, 27	6.0
" 7, 8, 9, 32	1.6
" 1, 38	1.3

Conclusions: Departures from normal in this region during 1958 seemed to result from differences in surface flow, which in turn strongly suggests that these departures were caused ultimately by differences in the related wind systems. There is also evidence, however, that the flow in this region is inherently unstable, in which case the 1958 conditions may represent a northward "meander" of the water masses.

Marine Biology

Midwater Trawling: Over 300 trawls were made, with 3 to 8 samples taken almost every night. Daylight trawls were also made for comparison. The distribution of marine fauna reflected the higher than average temperatures and the transitions from one water mass to another.

Preliminary examination of the trawl samples revealed the following:

(a) Catches close to the coast, particularly in the northern part of the cruise area, were surprisingly small compared with those obtained during the first IGY cruise of the *Brown Bear*. These small catches appear to be related to the relatively high temperature of the inshore waters, which suggests a tongue of water encroaching from the south. West of about 133°W, catches approximated those of the earlier cruise. The largest catches were made in the northwest corner of the area.

(b) In the northern areas, a pronounced thermocline seemed to act as a barrier to the plankton. (Plankton—floating or weakly swimming animal and plant life—is a basic food resource for other marine life.) Catches were extremely small in hauls made above the thermocline. In the single exception, a large catch taken in a shallow haul between stations 37 and 38, most of the animals appeared typically southern. The peak abundance occurred below the thermocline, at a depth of 200 feet; these catches were typically northern.

(c) A definite change in the character of the marine life occurred between stations 9 and 11, corresponding to the transition zone between Sub-Arctic and Intermediate Water. Hauls taken between stations 9 and 10 showed typically northern populations, whereas hauls just south of station 10 were lower in plankton volume and more typically southern. At least eight fish species not captured to the north were taken south of station 10; large catches of hatchet fish, *Argyropelecus spp.*, were particularly unusual. On the return leg of the cruise, the faunal split occurred between stations 30 and 32.

(d) Plankton catches with the midwater trawl were very small south of 37°N, except in hauls made close to the California coast. The offshore catches were approximately 1/100 the volume of hauls made to the north at similar longitudes.

(e) An extensive temperature inversion layer at 400–500 feet, first noticed south of station 10A, was probed with the midwater trawl and followed south to station 14. Catches above and below the inversion were small, but within the inversion they were large, approximating catches normally expected closer to the surface in northern waters. Although plankton catches decreased in volume to the south, the peak catches were always made within the inversion layer.

(f) Numerous bathypelagic (deep-sea) fishes were captured during the cruise. The largest fish caught was a 4-foot specimen of the king of the salmon, *Trachypterus rex-salmonorum;* several larvae and juveniles of this fish were also taken.

Albacore Tagging: Albacore were trolled for and tagged between Seattle and San Diego. From June 30 to July 23, a total of 38 albacore was caught, of which 29 were

tagged. This species of tuna, 15–30 inches long and weighing 4–30 pounds, is commonly found in temperate and tropical waters. Tagging supplies information on migration patterns, population composition, and sometimes on growth patterns of the fish.

A large concentration of albacore was found at approximately 46°N, 146°30′W, on July 11. Surface-water temperatures were 57° to 58°F; analysis for possible relationships with other local oceanographic conditions must await further processing of the available data. Other catches were sporadic and indicated no appreciable concentrations of albacore.

Stomach analyses of the untagged fish indicated that sauries (narrow-bodied, spiny-finned fish with widely-forked tails) were their principal food, with pelagic shrimp, squid, and amphipods (crustaceans resembling sand fleas) also noted.

Antarctic Notes

Continental Structure

New Zealand scientists, interpreting seismic records obtained during the IGY at Scott Base (NZ) and Hallett Station (NZ-US), report the existence of continent-type crustal structure beneath the ice mantle of a large portion of East Antarctica. The report, by F. F. Evison, C. E. Ingham, and R. H. Orr, of the New Zealand Department of Scientific and Industrial Research, appeared in *Nature*, January 31, 1959.

Records of the dispersion of seismic waves traveling through the crustal rocks from their point of origin, the epicenter of an earthquake in the southeast Indian Ocean on September 9, 1957, were analyzed. They showed the earth's crust to be approximately 35 kilometers thick in the region from the Wilkes Coast east of US-IGY Wilkes Station to the Ross Sea area, a distance of about 2000 km. (Preliminary analyses for an earthquake that occurred in the southwest Indian Ocean on August 4, 1957, also show a crustal thickness of about 35 kilometers for East Antarctica.) The normal thickness beneath continents ranges from about 30 to 40 kilometers. "Thus," the report states, "the existence of a true Antarctic continent is confirmed."

In the US program, analyses of dispersion of surface seismic waves from earthquakes in oceanic areas adjacent to the US-IGY Wilkes Station also suggest continental structure in this part of the Antarctic. These analyses indicate an average crustal thickness of about three-fourths the value considered normal for continents. On the basis of data gathered throughout the Antarctic during the IGY, G. P. Woollard, member of the USNC-IGY Technical Panel on Seismology and Gravity, has stated: "After even a crude calculation . . . it appears that the eastern half of Antarctica is a continent and the western half is an archipelago of islands bridged over by ice."

Traverse to Executive Committee Range

As part of the continuing US program in Antarctica, now under the direction of the National Science Foundation, an oversnow traverse to the Executive Committee Range, about 230 miles northwest of Byrd Station, was made by members of the station's scientific staff in February and early March of 1959. The traverse was led by John Pirrit, Station Scientific Leader at Byrd Station and Glaciological Project Leader for the 1959 Antarctic Program.

The party spent two days at the range

determining the positions of the peaks, making glaciological studies, and conducting a preliminary geological reconnaissance. Ten peaks were found in the range, the smallest reaching a height of 7144 feet above sea level and the largest reaching 13,856 feet. The range trends north-south for about 60 miles between about 76°20'S and 77°20'S and approximately along the 126°W meridian.

Preliminary geological investigations indicated that the mountains are volcanic in origin and are about 90% covered by snow and glaciers. Alpine-type valley glaciers flow from the peaks to join the vast ice sheet of Marie Byrd Land. Glacier action has eroded and modified the volcanic craters so that their original shapes are no longer recognizable. The high peaks are composed almost entirely of varieties of basalt overlaid by a thick series of volcanic breccias and tuffs. (Basalt is a fine-grained, dark, igneous rock commonly occurring as lava flows; breccias and tuffs are rocks formed of material ejected from volcanoes and subsequently compacted; the tuffs are fine-grained and the breccias are coarser and angular.)

An unusual and as yet unexplained finding was also made. Hundreds of black, partly rounded rocks of vesicular basalt (basalt containing cavities formed by gas bubbles when the rock was cooling) were discovered in one area. The rocks, generally 4–8 inches in diameter, were scattered over the surface of the ice sheet in the vicinity of several of the peaks. They were very numerous as far out as about two miles from the peaks, and isolated rocks were found as far away as approximately 17 miles.

The rocks were not distributed in the normal patterns characteristic of glacier deposits, or moraines; moreover, the glacier flow-rate was estimated to be not more than 50–100 feet per year, and many years would therefore have been required for the glaciers to move the rocks to their present positions. To further complicate the problem, the rocks do not show the alteration to be expected from differential rates of glacier flow, and appear to have been recently emplaced. Additional investigations will be required to determine how and when the rocks were deposited.

Position of IGY Amundsen-Scott South Pole Station

A more accurate determination of the geographic position of the IGY South Pole Station has recently been made. Computations based on 52 direct and inverted (to eliminate instrumental errors) theodolite observations of the star Canopus, from the station's astronomical loft, place the position of the loft at 89°59'43.6" ± 0.7" South Latitude, 24.8° ± 2.4° West Longitude. (Since the meridians of longitude converge at the poles, it is difficult to obtain the same apparent accuracy in longitude determinations at very high latitudes as in latitude determinations. However, only very small ground distances are involved so the actual accuracy is approximately the same.)

The Canopus observations were made between May 25 and July 6, 1958, by Palle Mogensen, then Station Scientific Leader at the IGY Amundsen-Scott Station, and the computations were performed by the Gravity and Astronomy Branch, Geodesy Division, of the US Coast and Geodetic Survey.

The astronomical loft is in the southernmost building of the station, which is laid out in a linear pattern roughly along the Greenwich Meridian and on the Greenwich side of the Pole. This latest determination places the position of the loft approximately 1650 feet from the geographic South Pole. It appears that the position is reliable to within 100–200 feet, exclusive of the "deflection of the vertical" (plumb-line deflection owing to gravity variations, as yet undetermined for the South Pole vicinity) at the observing site.

Firn Quakes

Two "firn quakes" were experienced by members of the oversnow traverse from IGY Byrd Station during the Antarctic summer of 1957–58. A firn quake is an ice-cap phenomenon somewhat resembling an earthquake but, by comparison, greatly limited in depth, areal extent, and severity.

These quakes are apparently confined to the firn—snow or granular ice that has lasted through at least one summer but has not yet become sufficiently compacted to be termed glacial ice. Firn reaches to depths of a few hundred feet in many places on the icecap. Firn quakes may be caused in several ways, but it is thought they frequently result from the collapse of widespread hoar-frost layers a few years old under the weight of overlying firn and snow.

Both quakes were felt during the third leg of the 1957–58 Byrd Station traverse. The first quake is believed to have occurred naturally, but the second was apparently triggered by an explosion set off in the course of seismic studies by members of the traverse party.

The first of the two firn quakes occurred about 90 miles southwest of the Sentinel Mountains, the turning point between the second and third legs of the traverse. The icecap in the region of the quake is about 5300 feet thick and the surface is about 6600 feet above sea level. The actual shock of the quake was preceded for about 10 seconds by a low, wind-like noise coming roughly from the direction of the Sentinel Mountains. The sound grew in intensity, as if approaching rapidly, until comparable to that of a jet aircraft passing overhead. The culmination of the phenomenon was a sharp, cracking sound accompanied by a sudden, distinct shock. No diminishing sound comparable to the pre-shock noise was noticed after the shock, and no indication of cracking could be found in the nearby ice surface. Moreover, examination of the walls of a three-meter snow pit excavated subsequently at the site of the quake disclosed no apparent collapse of any particular snow or firn horizon.

The second firn quake occurred about 170 miles farther along the traverse route two weeks later. At this point, an ice thickness of about 8600 feet and a surface elevation of 6700 feet were measured. The area was flat and featureless and about 65 miles west of the nearest mountains.

During seismic refraction studies, a member of the seismic team set off a 10-lb charge of explosives at a depth of about 13 feet in the snow cover and approximately 2.5 miles from camp. The shock that followed was greater than that ordinarily accompanying such an explosion. It was felt both by the scientist setting off the charge and by other members of the traverse party, 2.5 miles away. The noise preceding the quake, and the shock itself, were similar to those of the first quake, but this time the shock was followed by a receding noise in the direction opposite to that from which the pre-shock noise had come (the seismic shot point). Glaciologists working in a three-meter pit at the time of the quake observed no collapse of any of the snow or firn layers exposed in the pit walls.

Operation "Snuffles"

Work now is under way at Johns Hopkins University and the National Institutes of Health on hundreds of samples of blood sera, virus cultures, and bacterial cultures taken from US-IGY personnel in or en-route to and from the Antarctic.

The research is aimed at finding out more about the common-cold-like upper respiratory complaints. Answers are sought to questions such as these: Do the viruses associated with colds disappear from isolated groups? Do such groups lose their immunity to colds while sheltered from outside contacts? And the even more basic questions, exactly what causes the colds they catch, and how can these be counteracted?

Since isolated communities usually remain free from "colds" until visited by new people, the IGY Antarctic program provided an ideally controlled test situation.

The icebreaker *USS Staten Island* served as a floating laboratory for the project. All officers and men aboard gave samples of their blood at the beginning of the voyage and before their return to the US. In addition, 56 volunteers were studied closely throughout the entire voyage. Each gave a blood sample about once a month, and submitted to 15 throat swabs for virus cultures and 30 nose and throat swabs for bacteria. The specimens were collected mostly before and after visits to ports on the way south and in the Antarctic.

The information obtained aboard ship will indicate what infections were present in this semi-isolated community, and what infections could have been transmitted from it to the isolated and semi-isolated IGY Antarctic communities visited.

The *Staten Island* visited IGY Hallett Station (NZ-US), regarded as semi-isolated, and US-IGY Wilkes Station, which had been completely isolated for one year. Blood samples and swabs were taken from personnel of both stations.

Equipment was left at the Antarctic Research Laboratory, NAF McMurdo, for use in taking samples during the current Antarctic winter isolation. Samples also are being collected now at the South Pole, Hallett, and Wilkes Stations.

During the six-month voyage of the *Staten Island*, somewhat less than half the ship's company complained of "colds", many soon after leaving the various ports of call. From the swabs taken during these symptoms it is hoped to isolate some of the causal agents and match them with the antibodies later developing in the blood, or to differentiate them from true bacterial infections.

It remains to be seen if viruses found in the *Staten Island* volunteers can be picked up from personnel who joined the ship at Wilkes, or if the antibody experience of the Wilkes personnel parallelled that of ship personnel. Also significant will be the comparison of blood and swabs taken from Wilkes men before and after their isolation ended.

In its six months of operation, the *Staten Island* laboratory collected more than 900 samples of blood sera, more than 1300 virus cultures, and 2660 bacteria cultures.

To bring the sera and cultures back safely was a feat of logistics. It was necessary to maintain temperature for the virus cultures at a maximum of −60°C. The two freezers used for this purpose would not fit through the hatch, so a part of the metal bulkhead had to be removed and welded up again after the freezers were installed. When the ship returned to Seattle, the Air Force flew the freezers to Andrews Air Force Base, Maryland, in a C-97 cargo aircraft carrying two generators to provide the necessary emergency power.

William J. L. Sladen, the Project Director, assisted by Rainer Goldsmith of the Medical Research Council, London, was responsible for the field work. Sladen and others at Johns Hopkins University will work on the bacteriological material. Robert M. Chanock is doing the virus analysis at the Respiratory Virus Unit, National Institutes of Health.

J. W. Potter, Navy medical officer at NAF McMurdo, is continuing the investigation at the Antarctic Research Laboratory, and J. Boda, Australian medical officer, is doing likewise at Wilkes Station. "Operation Snuffies" also had the helpful cooperation of the Navy medical officers at Wilkes (R. Sparkes) and Hallett Stations (R. Bornmann and A. Bridgeman), and aboard the *USS Staten Island* (R. Duckworth) and *USS Glacier* (C. Stover). Australian, New Zealand, and British personnel also participated.

IGY Bibliographic Notes

This is the thirteenth of a series of bibliographic notes on IGY programs and findings. The references are selected largely from an IGY bibliography under preparation in the Science and Technology Division of the Library of Congress.

IA. L. Al'pert: Ionosphere Investigations by Artificial Earth Satellites. (In Russian). *Priroda*. No. 10, Oct. 1958. Pp. 71–77. Diagr.

R. V. Bhonsle and K. R. Ramanathan: Studies of Cosmic Radio Noises on 25 mc/s at Ahmedabad. *Journal of Scientific and Industrial Research*. Vol. 17a, no. 12. Dec. 1958. Pp. 40–45. Diagr., refs.

L. Biermann and R. Lüst: Radiation and Particle Precipitation upon the Earth from Solar Flares. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 209–210.

Warren W. Berning: Earth Satellite Observations of the Ionosphere. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 280–288. Illus., diagr.

R. L. Easton and M. J. Votaw: Vanguard I IGY Satellite (1958 Beta). *Review of Scientific Instruments*. Vol. 30. Feb. 1959. Pp. 70–75. Diagr.

John S. Farlow, III: *Project Ice Skate Oceanographic Data*. Woods Hole Oceanographic Institution. June 1958. 18 pp. Diagr. (Ref. No. 58-28).

Herbert Friedman: IGY Solar Flare Program and Ionizing Radiation in the Night Sky. *ARS Journal*. Vol. 29. Feb. 1959. Pp. 103–107. Diagr.

S. M. Greenfield and W. W. Kellogg: Weather Reconnaissance by Satellites. *Astronautics*. Vol. 4, No. 1. Jan. 1959. Pp. 32–33, 77–78. Illus., diagr.

Hugh Odishaw and Pembroke J. Hart: The International Geophysical Year World Data Center A. *News Report, National Academy of Sciences*. Vol. 8, No. 4. July-August 1958. Pp. 61–64.

B. Ramachandra Rao and E. Bhagiratha Rao: Effect of Enhanced Solar Activity on the F2 Region Drifts at Waltair. *Journal of Scientific and Industrial Research*. Vol. 17A, No. 12. Dec. 1958. Pp. 59–62. Diagr., refs.

Report on the International Geophysical Year. (Hearings Before the House of Representatives Committee on Appropriations, Subcommittee on Independent Offices.) Washington, Government Printing Office. 1959. 110 pp.

Henry L. Richter, Jr., William Pilington, John P. Eyraud, William S. Shipley, and Lee W. Randolph: Instrumenting the Explorer I Satellite. *Electronics*. Vol. 32, no. 6. Feb. 6, 1959. Pp. 39–43. Illus., diagr.

Milton Rosen: What We Have Learned from Vanguard. *Astronautics*. Vol. 4, No. 4, Pt. 1. April 1959. Pp. 28–29, 110–111. Illus., diagr.

Alan H. Shapley: The Day-to-Day Coordination of IGY Observations. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 323–327.

W. G. Stroud: Meteorological Rocket Soundings in the Arctic. *Jet Propulsion*. Vol. 28. Dec. 1958. Pp. 817–822. Diagr.

Submerged "River" Found in Pacific. *Journal of Geophysical Research*. Vol. 63. Sept. 1958. Pp. 558–559.

J. O. Thomas: The Distribution of Electrons in the Ionosphere. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 162–175. Diagr.

Vol. 40, No. 3 TRANSACTIONS, AMERICAN GEOPHYSICAL UNION September 1959

NATIONAL ACADEMY OF SCIENCES

Number 27 • September 1959

IGY BULLETIN

A monthly survey of programs and findings of the International Geophysical Year and the International Geophysical Cooperation–1959 as related primarily to United States programs

The Argus Experiment

The following report is based primarily on papers presented at the Symposium on Scientific Effects of Artificially Introduced Radiations at High Altitudes, held at the National Academy of Sciences, Washington, D. C., on April 29, 1959. The papers, which appeared in complete form in the August 1959 issues of both the Proceedings of the National Academy of Sciences *(reprinted also as* IGY Satellite Report Series No. 9, *September 1959) and the* Journal of Geophysical Research, *were, in the order of their presentation, read by Richard W. Porter of the General Electric Company, Nicholas Christofilos of the University of California, James A. Van Allen of the State University of Iowa, Major Lew Allen, Jr., and Captain Joseph A. Welch, Jr., of Kirtland Air Force Base, New Mexico, Philip Newman of the Air Force Cambridge Research Center, and Allen M. Peterson of Stanford University.*

Although the Argus Experiment was not part of the IGY Program, and neither the USNC-IGY nor the National Academy of Sciences was instrumental in its planning and conduct, an IGY satellite made many observations of Argus phenomena. Moreover, Argus data relate to upper-atmosphere work investigated in IGY programs. Hence, the experiment appeared to be of sufficient interest to IGY scientists to warrant this summary report in the Bulletin.

Equipment for measuring cosmic-ray intensity at high altitudes, carried in US-IGY satellite 1958 Alpha (Explorer I), first discovered the existence of high-intensity radiation—the Van Allen radiation regions—trapped in the earth's magnetic field. (In this report, the term "radiation" in general refers to charged particles.) Further investigations with 1958 Gamma and 1958 Epsilon (Explorers III and IV, respectively) and with the US-IGY deep-space probes, Pioneers I, III, and IV, increased knowledge of the nature of the radiation and its extent in space. (*See Bulletin No. 21.*)

The manner in which charged particles are trapped in the earth's magnetic field has been long understood through the work of C. Stoermer, H. Alfven, and others. This theory was confirmed by the satellite and space-probe observations mentioned above.

In October 1957, a few months before the launching of 1958 Alpha, N. C. Christofilos, of the University of California's Lawrence Radiation Laboratory, noted that many observable geophysical effects could be produced by small-yield atomic detonations in the earth's tenuous upper atmosphere.

It was believed by Christofilos and upper-atmosphere physicists to whom the idea was communicated, that artificial, impulsive injection of known particles along known magnetic lines of force, at a known time would constitute a powerful technique for clarifying uncertainties of the dynamics of geomagnetic trapping as well as for studying related geophysical effects. The

natural radiation trapped in the Van Allen regions could not, of course, be subjected to such experimental control.

Theory: According to the trapping theory, an electron injected at high altitude into the earth's magnetic field, which closely resembles that of a bar magnet, would spiral in a helical pattern about a magnetic line of force (see Fig. 1). Since the field

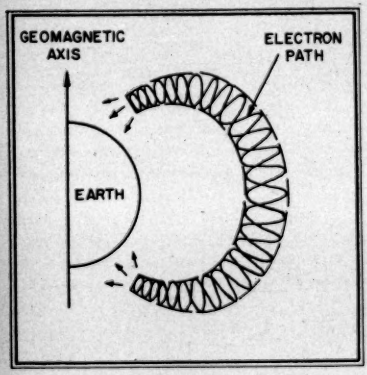

FIG. 1. *Schematic Diagram of Path of Electron in the Earth's Magnetic Field. (Actual path is very much narrower and describes innumerable tight spirals.) Angular distributions at the mirror points form disc-like patterns. Most electron losses occur by scattering in the denser atmosphere near the mirror points.*

strength increases toward the earth, the particle would finally reach a point near the end of the line of force, but still at considerable height, beyond which it could not penetrate. These points, one of which exists for each particle at each end of the line of force about which it spirals, have been termed "mirror points" since they cause the particle to be reflected back along its course. This process continues at great speed until the particle is finally "lost," usually in the vicinity of the mirror points, through repeated collisions with molecules of the earth's atmosphere.

In addition to the motions described above, trapped electrons would drift eastward around the earth owing to the decrease in strength of the magnetic field with altitude, the centrifugal force of the spiraling particles, and certain other factors. Hence, if a sufficiently large volume of electrons were injected into the magnetic field at a single point, the combined motions would result in the formation of a thin shell of electrons completely encircling the earth and bounded approximately by the magnetic lines of force between which the particles were injected.

The lifetime of an electron trapped in the magnetic field is directly proportional to the length of the line of force about which it spirals and approximately to the square of the electron's energy, and inversely proportional to the air density at the mirror points. Injected electrons would be scattered out of their initial spiral trajectories by collisions with air particles, and, since the density of the atmosphere decreases exponentially with increase of altitude, such collisions would occur with greatest frequency near the mirror points, in the lower portions of the electron paths. Hence, most electron losses would occur near the mirror points. The scattering results in further lowering of the mirror points into regions of still greater density. It was expected that most electrons with energies of 1-2 million electron volts (mev) injected at an altitude of a few hundred kilometers would survive for several hours or more.

In addition to the trapping effect, the creation of an artificial aurora at each end of the lines of force passing through the detonation region was predicted. Electrons from the detonation would be guided along these lines of force in both directions, ionizing the air through which they passed and also causing auroral luminescence at both points where the lines of force re-enter the denser atmosphere. It was also expected that certain magnetic, electromagnetic, and ionospheric effects would be observable.

Organization of Experiment: After preliminary calculations had been made by

Christofilos, a proposal for a series of studies based on the artificial injection of electrons into the magnetic field at high altitudes by small-yield nuclear detonations was presented to the President's Science Advisory Committee. At the suggestion of this committee, a group of representatives of both the scientific and military communities (since the experiments involved the interests of both) was formed to appraise all aspects of the undertaking. By this time, the IGY satellite experiments designed by James A. Van Allen of the State University of Iowa had partially confirmed the trapping theory. Therefore, it was decided late in April 1958 to proceed with the artificial-injection experiment, which was given the code name of "Argus." Overall responsibility for the preparation and conduct of the Argus Experiment was given to the Advanced Research Projects Agency (ARPA) of the Department of Defense. Herbert York, then Chief Scientist for ARPA, directed the program.

Since the magnetic axis of the earth is tilted with respect to the axis of rotation and the center of the magnetic dipole is displaced toward the Pacific Ocean, it was apparent that the mirror points would be closest to the earth's surface over the South Atlantic. Hence, this region was selected for the high-altitude detonations. This location also afforded conjugate, or mirror, points near the Azores Islands in the North Atlantic, making it easier to conduct observations of the aurora expected to occur at that end of the line of force.

The mission of delivering three small-yield nuclear devices to high altitude over the South Atlantic and detonating them was undertaken by a US Navy task force specially organized for this purpose. The three nuclear devices were detonated in late August and early September 1958, all at a nominal altitude of 480 kilometers (about 300 miles). They were delivered to their detonation points in the upper atmosphere by multi-stage rockets launched from the *USS Norton Sound*. The first burst occurred at approximately 0230 UT, August 27, at a geographic location of approximately 38°S, 12°W; the second was at about 0320 UT, August 30, near 50°S, 8°W; and the third was on September 6, at about 2210 UT, and in the vicinity of 50° S, 10°W. The position of the shells of trapped Argus electrons relative to the Van Allen regions of trapped natural radiation is shown in Figure 2.

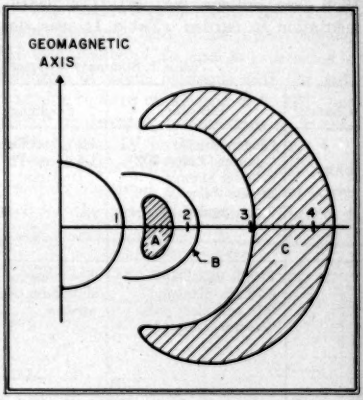

Fig. 2. *Approximate Position of Argus Shells with Respect to the Van Allen Regions of Trapped Natural Radiation. A is the inner Van Allen belt; B is the position of the Argus shells; and C is the outer Van Allen belt. Scale in earth radii.*

Two IGY satellites, Explorer IV (1958 Epsilon) and Explorer V, contained instrumentation designed at the State University of Iowa to measure the natural radiation in the Van Allen belts. This instrumentation was also capable of measuring the artificial radiation in the Argus shells. (Explorer V did not go into orbit.) The Air Force Special Weapons Center prepared a series of high-altitude sounding rockets to study the lower fringes of the radiation shells (Project Jason). Stanford Research Institute and the Air Force Cambridge Research Center developed and installed at various ground locations and aboard aircraft and ships a

variety of equipment to measure the expected auroral, radio, magnetic, and electromagnetic effects. The following material reviews the aims, techniques, and preliminary results of the various investigations related to the Argus Experiment.

Satellite Observations

1958 Epsilon entered an orbit inclined at 51° to the equator at 1506 UT, July 26, 1958 (see *Bulletin No. 15*). The instrumentation it carried (Table 1) was designed under the direction of James A. Van Allen, Carl E. McIlwain, and George H. Ludwig, all of SUI.

The location in space of the magnetic shells created by the experiment was chosen so that the shells could be intercepted by a relatively low-altitude satellite with an orbital inclination not greater than 51°, the highest inclination practical with the available facilities. The intermediate latitude chosen for the detonations also permitted the satellite orbit to intercept the shells of trapped particles at a less oblique angle. Moreover, since the measurements of Explorers I and III had shown a rapid decrease with distance from the magnetic equator in the intensity of the natural radiation at a given altitude, the "background" radiation was expected to be less at intermediate latitudes than at lower latitudes.

Table 1. Summary of Detector Characteristics (Explorer IV)

Channel	Detector	Shielding	Sensitive to:	Geometric Factor
1	Geiger-Mueller Counter (Anton 302); cylinder approximately 7 mm × 9 mm; scaler: 64	1.2 g/cm² Fe + 1.6 g/cm² Pb (minimum)	Electrons of $E >$ 5 mev; protons of $E >$ 40 mev; X-rays of $E >$ 80 kev, with low efficiency	Omnidirectional geometric factor 0.14 cm² for minimum stopping power; 0.82 cm² for penetrability greater than 7 g/cm²
2	Plastic scintillator—0.76 cm. diameter, 0.18 cm thick; pulse detector; scaler: 16	0.14 g/cm² of aluminum over window	Electrons of $E >$ 580 kev; protons of $E >$ 10 mev; axis of detector ⊥ to payload axis; X-rays of $E >$ 300 kev, with low efficiency	0.040 cm² steradian for minimum stopping power; 4.2 cm² steradian for penetrability greater than 5 g/cm²
3	Same as Channel 1 except less shielding; scaler: 2048	1.2 g/cm² Fe (minimum)	Electrons of $E >$ 3 mev; protons of $E >$ 30 mev; X-rays of $E >$ 20 kev, with low efficiency	Omnidirectional geometric factor 0.14 cm² for min. stopping power; 0.70 cm² for greater than 5 g/cm² stopping power
4	Cesium Iodide crystal — 0.76 cm diameter, 0.20 cm thick; total energy-d.c. electrometer	1.0 mg/cm² of nickel and aluminum over window	Electrons of $E >$ 20 kev; protons of $E >$ 400 kev; X-rays; axis of detector ⊥ to payload axis	0.0235 cm² steradian for minimum stopping power; 4.4 cm² steradian for penetrability greater than 5 g/cm²
5	Same as 2 except scaler: 2048			

Nature and Scope: In the month before Argus I, 1958 Epsilon collected much data serving to establish the detailed spa-

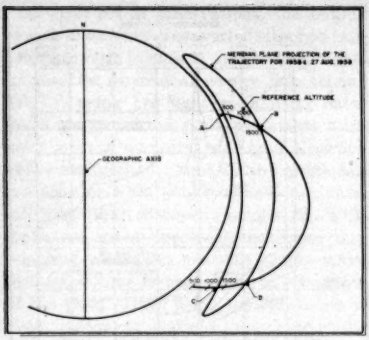

Fig. 3. *Typical Geometric Relationships Between 1958 Epsilon Orbit and Argus Shells. A, B, C, and D represent points of intersection; reference altitudes are in kilometers.*

tial relationships and many of the properties of the natural trapped radiation. Between August 27 and September 19, significant data were obtained on 164 intersections of the Argus shells by 1958 Epsilon. Most of the observed intersections occurred in the northern hemisphere, where tracking facilities are more complete.

Typical geometric relationships between the satellite orbit and the shell of magnetically trapped radiation are shown schematically in Figure 3. It can be seen that ideally the shell is intersected four times, at various altitudes, latitudes, and longitudes, during a satellite revolution. Actually, however, significant data were obtained on an average of much less than four intersections per orbit owing to the low altitude, and hence the low electron intensity, of many intersections; distortion and tilt of the magnetic shell, so that fewer than four intersections occurred on some orbits; occurrence of some intersections beyond radiotelemetry range of the receiving stations; and occurrence of some intersections at points where the intensity of artificial radiation was smaller than that of the natural radiation (this condition prevailed everywhere along the satellite orbit after each artificial-radiation shell had decayed with time to a certain degree).

The lower-powered of the two transmitters and telemetry channels 2 and 5 were exhausted on about September 3. The higher-powered transmitter and channels 1, 3, and 4 operated properly until about September 21. By this time the Argus III particles were still being detected above the background radiation, but only on occasional favorable intersections. It appears, however, that space-probe Pioneer III (see *Bulletins 20 and 21*) detected a residuum of Argus electrons near the geomagnetic equator on December 6, 1958, but none were detected in this region by space-probe Pioneer IV on March 3, 1959.

The "Argus effect" was easily and promptly observed by 1958 Epsilon after each of the three detonations. Figure 4

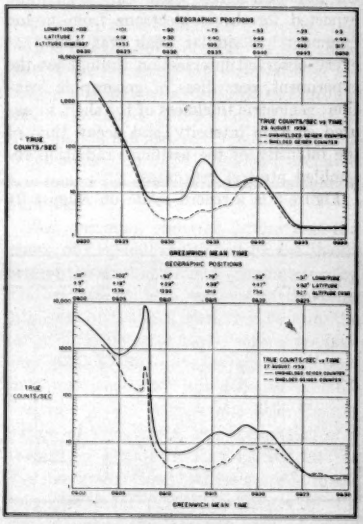

Fig. 4. *Comparison of Counting Rates the Day Before Argus I (upper graph) and a Few Hours After Argus I. The peak at 0608 UT on the lower graph represents intersection of the electron shell by 1958 Epsilon.*

shows a record of measurements of the natural radiation taken the day before Argus I (upper graph), and a record taken through a similar geographic region about 3½ hours after the Argus I detonation (lower graph). Nothing equivalent to the great peak intersected at 0608 UT, August 27, had been observed by 1958 Epsilon during the preceding four weeks. Moreover, the peak was encountered on the first observed intersection with the planned magnetic shell following the Argus I burst. During the entire active period of 1958 Epsilon (July 26-September 21, 1958) no such peaks were observed except those corresponding in time and place to the expected artificial radiation.

Further reasons for identifying these peaks with the Argus effect are: the observed energy spectrum and the nature of the radiation agreed essentially with those expected for decay electrons from fission fragments; a similar peak was found at every observed intersection throughout the experiment, regardless of geographic location; geometric thickness of the shell, measured electron intensity, and decay time of the intensity of the artificial radiation resembled pre-test estimates.

Figure 5 is a record made on August 31 showing the decaying peak (0446 UT) of the Argus I radiation and the fresh peak (0449 UT) resulting from the Argus II detonation. Plots of the reduced and corrected data from all four detectors for an intersection on August 30 are shown in Figure 6.

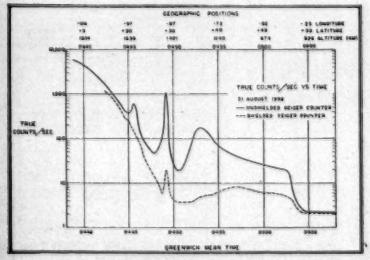

Fig. 5. *Counting Rate Record Showing Fresh Argus II Peak and Decaying Argus I Peak. Large peak at 0449 UT represents satellite intersection of Argus II shell; small peak three minutes earlier is intersection of remnant of Argus I shell.*

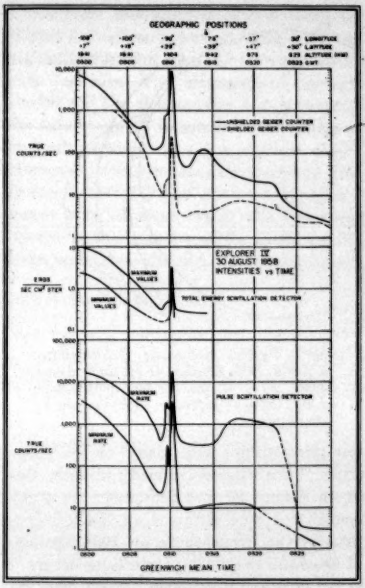

Fig. 6. *Comparison of Geiger Counter and Scintillator Records Showing Intersection of Argus Shells by 1958 Epsilon on August 30, 1958.*

The angular motion of the satellite as it rolled and tumbled through the electron shell, apparent in the instrumental records, was advantageous for the measurement of angular distributions of the Argus electrons. These distributions, as observed near the mirror points, were found to form disc-like patterns (Fig. 1), as previously suggested by the magnetic-trapping theory and as observed extensively in studies of the natural radiation.

In each set of observations, the output of each detector was converted either to true counting rate (channels 1, 2, 3, and 5) or to absolute directional energy flux (channel 4), using pre-flight calibration data. From the corrected plots, estimates were made of net intensity of Argus electrons above background; "time width" of the Argus peak between points of half-maximum intensity and between points of 1/10 maximum intensity; local maximum and minimum intensities near the center of the peak; and time of occurrence of the center of the peak. Then, using the ephemeris of 1958 Epsilon, tabulations were made of the latitude, longitude, and altitude of the center of the peak, and of the geometric thickness of the shell at half-maximum intensity, measured perpendicular to the shell.

Preliminary Summary of Results: Based on the data collected by 1958 Epsilon during its intersections of the Argus shells, certain preliminary results have been obtained regarding the shells, the nature of the electrons, and the geomagnetic field.

The mean thickness, at half-maximum intensity and measured perpendicular to the shell boundaries, of the Argus I and II shells was about 90 kilometers, and the mean thickness of the Argus III shell was about 150 kilometers. The thickness did *not* depend systematically on elapsed time, (except possibly during the magnetic storm on about September 4; see below), but the measured values show a scattering of about 30%. The investigators assume that the basic shell thickness was determined by the very complex injection situation at and immediately following each detonation. This surmise is supported by rough calculations of the dynamics of the detonations in the earth's magnetic field.

The magnetic shells reached outward about two earth radii from the center of the earth. The leakage of particles from the ends of the shells and by energy loss proceeded at a sufficiently rapid rate so that, in general, diffusion across the boundaries of the shells was too slow by comparison to be observed.

Plots were made in which each observation of the center of each Argus shell (I, II, and III) was projected downward to the surface of the solid earth by use of a simplified model of the geomagnetic field (the eccentric dipole model, in which the magnetic axis does not correspond to the geographic axis). The three resulting loci of points, interlaced in time, are notably smooth and regular, suggesting positional stability of the shells during the observing period. It was concluded that the shells could not have drifted in latitude by more than about 0.03° per day (about 2 kilometers per day at a height of 1500 kilometers) without having resulted in a "ripple" in the implied geomagnetic field contour not supported by other data.

The disc-like character of the angular distribution of the trapped electrons, and the angular thickness of $\pm$ 20° or less, show that at the relatively low observational altitudes most particles measured had turning points (or mirror points) not more than a few hundred kilometers below the locations of the observations. This is quite reasonable in terms of the basic dynamics of magnetic trapping.

The maximum observed intensity at the center of the shell multiplied by the thickness of the shell at half-maximum intensity has been taken as a measure of the total intensity of trapped particles (within the range of the detector used). Several preliminary plots of this quantity against elapsed time were made for two different possible positions in the geomagnetic field. Examination of these plots, and application of a theory by Ernest C. Ray of SUI on the loss mechanism for particles trapped in the magnetic field, permits estimates of the time-decay of the intensity of the trapped radiation. These estimates pertain to an effective electron energy of 3.5 mev. Ray computed the effective atmospheric density, for an altitude of 1000 kilometers, that

would be required to reduce the radiation intensity as rapidly as observed. He found this density to be least 10 times as great as that reached by extrapolation from an atmospheric model derived by Robert Jastrow from studies of atmospheric drag on satellites. The SUI workers believe it is possible that atmospheric density is anomalously high in the region of the Argus shells, which occurred in the "slot" between the two zones of trapped natural radiation (Fig. 2).

An alternative speculation is that the rapid decay was caused, in part at least, by "magnetic diffusion" owing to small-scale and perhaps time-dependent irregularities of the geomagnetic field. Investigation of this possibility is in process, using the results obtained from all four detectors, which were designed for different effective particle energies.

The gross decay rate is presumably a composite of atmospheric and magnetic effects.

A discontinuously rapid drop in intensity of the Argus I and Argus II radiation on about September 4 suggests that a very large magnetic storm on that date may have caused great enhancement of the rate of loss of stored particles. Also, the Argus II shell appears to have thickened significantly during this period.

The 1958 Epsilon observations permit estimation of the total number of trapped Argus electrons having turning points below the highest altitude of observation. This estimate, made as of zero elapsed time, serves to supply a lower limit to the fraction of electrons effectively injected into the geomagnetic field, since the nominal yield of the injection and the nominal energy spectrum of the electrons are known.

When the product CWt (maximum intensity at the center of the shell × thickness × time) is plotted against the strength of the magnetic field in the region occupied by the shell, it can be seen that there is an increase in the density of turning points with increasing altitude (i.e., with decreasing field strength). It is therefore evident that injection of the longer-lived electrons occurred largely at altitudes much greater than that of the detonations.

As a result of observations of satellite 1958 Epsilon, the geometric form of the Argus shells is known to a precision of about ± 10 kilometers with respect to the earth. Hence, these experiments provide a significant new method for the harmonic analysis of the general geomagnetic field. Although this analysis is not yet complete, it is already clear that at least the dipole and quadrupole terms of the magnetic field can now be determined with useful accuracy.

Optical, Radio, and Magnetic Observations

Because it was expected that the Argus detonations might result in optical, radio, and magnetic effects that could be observed from ground level, the Stanford Research Institute and the Air Force Cambridge Research Center cooperated in a program to measure these effects. The techniques used and some of the results of these experiments are described below.

Aurora: The auroral luminescence resulting from the Argus detonations was observed at both the detonation site and the conjugate point in the northern hemisphere by visual observers, all-sky cameras and other photographic methods, and by radar. In addition, photometers and interference filters were used to study the spectrum of the artificial auroras.

In the detonation area, all three events were accompanied by colorful auroras elongated along a line intersecting the magnetic meridian at an angle of 10°. Photometric records were obtained for each event at the 5577 A and 3914 A wavelengths of the auroral spectrum. (The former is the green line of atomic oxygen and the latter is one of the violet lines of nitrogen.) The ratio of atomic oxygen to nitrogen, about 10:1 for

the third Argus event, was much higher than that usually observed in natural auroras.

The investigators assume that the auroral effect was caused mainly by the strong excitation by fission products of oxygen and nitrogen at the 100-kilometer level in the earth's atmosphere. The photometric records also serve as a check on the detonation time.

In the conjugate area, near the Azores Islands, only one doubtful sighting was made after Argus I and none was made after Argus II. After the third detonation, however, a brilliant auroral display was observed by many members of the crew of the *USS Albemarle* and by civilian scientists aboard. Distances to the conjugate aurora resulting from Argus III, estimated by observers aboard the *Albemarle*, correspond to auroral heights of about 240–565 kilometers. Visual estimates of its duration ranged from about 5 to about 30 minutes.

Radar echoes were returned from all three of the auroras in the detonation area and from auroras accompanying Argus I and III at the conjugate point. In the detonation area the echoes appeared within seconds after the burst. In one case, these echoes were observed for five hours. In the conjugate area, echoes appeared somewhat later, but still within a minute of the burst, and lasted in one case for an hour and 15 minutes. The radar observations in the conjugate region agree approximately with the auroral height estimates based on the visual observations, and, in combination with the visual observations, located the conjugate point within about 100 kilometers of the theoretically expected location.

Magnetic and Electromagnetic Studies: It was expected that a detonation of the Argus type would cause a shock wave in the atmosphere which would be propagated as a hydromagnetic wave, or Alfven wave, along the magnetic line of force. This effect would be detectable on the ground by very-low-frequency (VLF) equipment or by magnetometers. A change in the magnetic field might result from the hydromagnetic wave or from an electric current in the atmosphere.

Several types of equipment were available in the Azores to monitor these effects. Extremely-low-frequency (ELF) instrumentation (0.3 to 30 cycles/sec) was set up to measure changes in the magnetic field. Also used were a heliflux magnetometer and a variable-mu magnetometer to measure the static field. Regular magnetic stations, as well as IGY aurora and air glow stations, were also available to observe detonation effects. Similar equipment, with the exception of the ELF apparatus, was installed on ships in the detonation area.

The ELF receiver in the conjugate area obtained results for the second and third detonations, but not for the first. (Argus I took place during a geomagnetic disturbance accompanied by unusually severe radio blackout. Moreover, the magnetic lines of force within which Argus I took place, and along which these effects presumably would be propagated, may have passed through or near the lower of the Van Allen radiation regions.)

ELF signals received after the Argus II and III detonations were unmistakably distinguishable from background electromagnetic effects. Harmonic analyses indicated signal components between about ½ and 2 cycles/second. Estimates of changes in amplitude of the various magnetic-field components ranged from about 1/25 to 3/2 gamma, with the largest changes generally occurring in the east-west component of the field and the smallest in the vertical component.

The ground speed of propagation of a strong disturbance (at plus 42 seconds) from the detonation point was about 700 km/sec. If it is assumed that the disturbance followed the magnetic line through the detonation point, its average speed along the line of force would be about 2000 km/sec.

A magnetic detector in the launch area recorded an initial one-second-pulse signal of about one cycle/sec for Argus III with a strength of more than 10 gammas, followed by longer-period pulses. The total duration, with irregular fluctuation, was about 1½ minutes.

Radio Propagation: Variations in propagation characteristics of radio waves in the very low frequency (VLF) range—300 cycles/sec to 30 kilocycles/sec—have for many years been recognized as sensitive indicators of lower-ionosphere conditions (below about 100 kilometers). The VLF signals can be enhanced by increased ionization at the normal heights of reflection of the radio waves; on the other hand, if ionization is increased at lower levels, where atmospheric density is greater, absorption results and signal strength is reduced.

For the Argus experiments, VLF equipment similar to that used during the IGY for whistler studies (see *Bulletin No. 6*) was designed, constructed, and installed by the Stanford University Radio Propagation Laboratory. Recordings were made with this equipment in the launch area, at several locations in the conjugate area, and at Stanford University, California.

Of particular interest were recordings made in the Azores and in Spain of signals at a frequency of 19.6 kilocycles/sec from station GBZ in England. These recordings showed abrupt decreases in signal strength of 6-12 decibels following Argus II and III. Recordings made at Stanford University of signals from stations NPG in Seattle (18.6 kilocycles/sec) and NDT in Japan (17.1 kilocycles/sec), on the other hand, showed slight increases in signal strength for some minutes following Argus II and III.

A possible explanation for the observations in the conjugate area is that electrons scattered from the magnetic shells, as well as the ionized debris itself, may have penetrated to low altitudes, increasing the ionization in the lower ionosphere and producing absorption. In the Pacific, far removed from the original injection region, the enhancement of signal strength may indicate increased ionization at higher levels above the earth.

Radio Noise: As part of the Argus measurements, three riometer stations were operated near the conjugate region at frequencies of 30, 60, and 120 megacycles/sec, and one was operated near the launch area at 30 megacycles/sec. (The riometer is designed for sensitive routine measurement of ionospheric absorption by monitoring the power level of cosmic noise propagated through the ionosphere.)

Although the perturbation of the ionosphere by the Argus detonations was sufficient to reduce, by absorption, the strength of VLF signals (see above), it was not large enough or widespread enough after any of the three Argus detonations to be detected by the riometers.

Another purpose of the riometer network was to provide a sensitive measure of radio noise that might be generated by electrons trapped in the Argus shells. Noise from this source was not detected, and, on the basis of particle-counting data from 1958 Epsilon during the Argus Experiment and of comparison of electron density in the Argus shells with counting rates in the Van Allen regions, it is now believed that this radio noise should, in fact, have been below the detectable level. However, the experiment showed that such radio noise information might reasonably be extracted, in the future, by careful radio astronomy methods.

Jason Rocket Observations

The "Jason" project, conducted by the Air Force Special Weapons Center, consisted of the launching of 19 high-altitude rockets carrying instrumentation to measure the electron flux of the Argus shells. The rockets were sent to altitudes of about 800 kilometers from Cape Canaveral, Florida, Wallops Island, Virginia, and Ramey Air Force Base, Puerto Rico. The

sites were chosen to provide sufficient latitudinal coverage to assure interception of the shells. The instrumentation in each rocket consisted of eight Geiger-Mueller counters with various amounts of shielding to provide an energy scale and various orientations to provide directional information. Data were telemetered to ground stations. Thirteen successful flights were made, one for pre-Argus background data, two following Argus I, and 10 following Argus II.

Only limited data were obtained from the Argus I flights, but much information resulted from the flights following Argus II. Rockets launched southward from Wallops Island observed a narrow region in which counting rates were very high—initially, 100,000 times normal. The rockets penetrated the Argus II shell at altitudes of about 320 to 485 kilometers, and the shell was observed to be about 20 kilometers thick in this region. Increases in radiation level were observed about 700 kilometers to the north and to the south. Both the width and the position of the shell remained constant (± 8 kilometers) throughout the 100-hour observation period. This extreme constancy, while the electrons traveled from north to south more than 1,000,000 times and drifted around the world more than 100 times, verifies many important hypotheses about the earth's magnetic field and the character of space as far out as one earth radius from the surface.

The intensity of trapped electrons in the shell was observed to be approximately inversely proportional to the time from the burst. This is consistent with the theory that the trapped electrons are lost predominantly through scattering in the atmosphere near the mirror points.

Measurements of angular distribution of the electron flux, based on determination of the orientations of the rocket instrumentation by analyzing telemetry signal-strength records, show that the flux was confined to a plane very nearly perpendicular to the lines of force of the magnetic field.

Conclusions

A great variety of measurements of the magnetically trapped radiation from the Argus detonations were made by special instrumentation included in the payload of IGY satellite 1958 Epsilon and by rockets and ground-based equipment employed by various agencies. Preliminary analyses have confirmed the theory of trapping of radiation by the magnetic field of the earth and have supplied new information about the configuration and some of the characteristics of the magnetic field. Data gained by this controlled experiment, in which many of the factors were known, may also provide an improved basis for understanding the mechanics of the natural trapping of charged particles in the Van Allen radiation regions, and of related phenomena such as the aurora.

Oversnow Traverses from IGY Little America Station

The following material was prepared by Albert P. Crary, leader of the traverses described and Station Scientific Leader at Little America Station during 1956–57 and 1957–58.

Three oversnow traverses were made inland from Little America Station during the International Geophysical Year. (Figure 7 shows the routes of these three traverses and of others made during the IGY.)

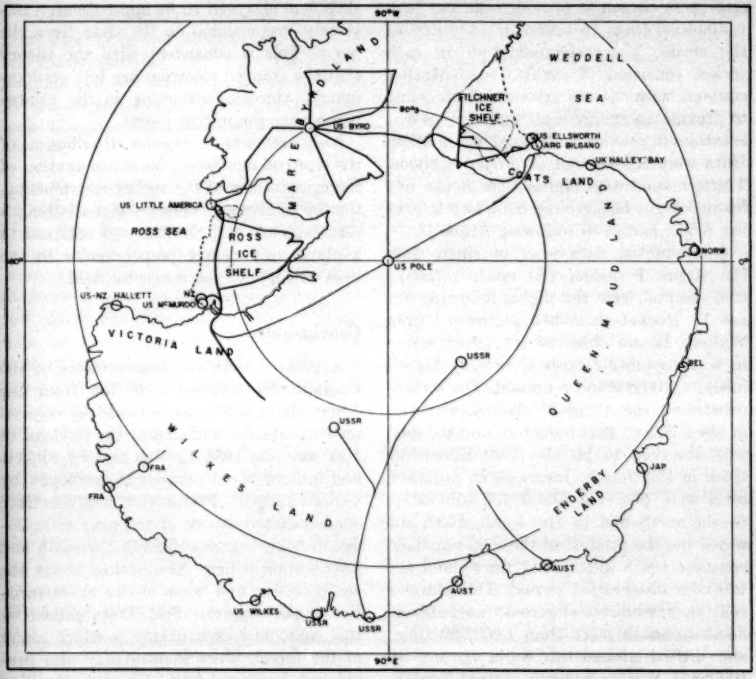

FIG. 7. *Antarctic Traverses During IGY. Treated in this report are those made from US-IGY Little America Station on the Ross Ice Shelf during 1957–58, and in the following year from Little America across the Ross Ice Shelf up the Skelton Glacier and along the Victoria Land Plateau.*

The Ross Ice Shelf Traverse, from October 24, 1957, to February 13, 1958, covered a total of about 1225 nautical miles. (A preliminary description of this traverse is given in *Bulletin No. 10.*)

The Byrd Tractor Trail Traverse was made from March 25 to April 10, 1958. The party traveled along the Little America-Byrd Station tractor trail for 140 nautical miles, to a point close to the junction between the floating and grounded ice.

The Victoria Land Traverse started on October 15, 1958, at Little America Station and ended January 31, 1959, at Scott Base (NZ) on Ross Island in McMurdo Sound. The first part of this journey duplicated the first leg of the Ross Ice Shelf Traverse of the previous year. On this stage, a few additional observations were made in some areas where the 1957–58 water depth and gravity readings departed from computed norms. The standard program of closely spaced observations, including data needed for glacial regime studies, started as the party left the earlier route and headed west to the Skelton Inlet, a few miles south of the Minna Bluff-Mount Discovery peninsula.

A month was spent moving from the shelf ice up the Skelton Inlet and the Skelton Glacier to the Victoria Land plateau. From the top of the plateau at the head of the Skelton Glacier, the traverse party traveled due west. It followed a line a few miles south of 78°S for about 350 nautical miles to 131.5°E. The party then returned along the same route, making stops on the Skelton Glacier and on the western Ross Ice Shelf to remeasure snow accumulation and ice movement at stakes installed on the outward journey. From Minna Bluff to Scott Base a detailed seismic-sounding and ice-movement program was undertaken.

A large portion of the data taken on these traverses is still in the process of reduction and analysis. This report describes some preliminary results of the studies on the Ross Ice Shelf and in Victoria Land.

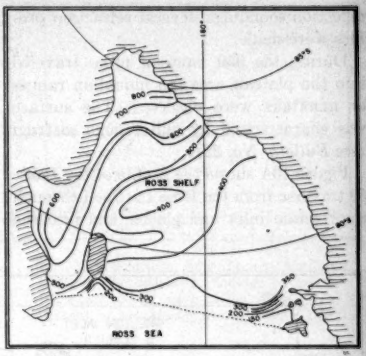

FIG. 8. *Thickness of Ice Shelf in Meters.*

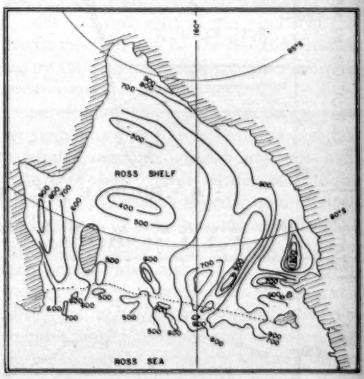

FIG. 9. *Depth of Water Below Sea Level in Meters.*

Ross Ice Shelf

Study of the Ross Ice Shelf was included on all three of the traverses. Figure 8 shows tentative ice thicknesses; the elevation of the surface above sea level was generally 1/7 to 1/8 of the ice thickness. The general thickening of the shelf along the southeastern part (upper left in Fig. 8) is indicative of the large contribution to the nourishment of the shelf made by the southwestern part of Marie Byrd Land and the polar plateau, as compared with that of the glaciers along the western part of the shelf. Near the junction of the floating and grounded ice in the Skelton Inlet (lower right in Fig. 8), floating ice is nearly 1000 meters (approximately 3280 feet) thick.

Figure 9 gives preliminary findings on water depths, with some data from US Navy Hydrographic Office charts added for the waters off the barrier edge. The deep waters around the periphery of the shelf, and the particularly deep sounding due south of Mount Discovery, are noteworthy. A few soundings even deeper were made in the Skelton Inlet, a distinct fiord with deep water for considerable distances into the mountain area.

Victoria Land

The Victoria Land plateau area proved more difficult to explore by seismic soundings than the low-elevation shelf areas. Deeper holes for explosives and various recording techniques were tried and to some extent were successful. To supplement the

reflection soundings, several refraction profiles were made.

During the 350 nautical miles traveled into the plateau area, no mountain ranges or nunataks were observed. The surface was characterized by quite rough sastrugi (see *Bulletin No. 22*).

Figure 10A shows the profile of the 1958–59 traverse from the Ross Ice Shelf through the Skelton inlet and glacier and into the plateau area, giving approximate surface elevations and ice thicknesses. At the western end of the line, near 130°E, the elevation of the surface was found to be about 2850 meters, comparable with the elevation at the South Pole Station. It is noted also that the surface elevation rises toward the west. The USSR-IGY Vostok Station, with an elevation of about 3420 meters, lies about 300 nautical miles farther west. This would

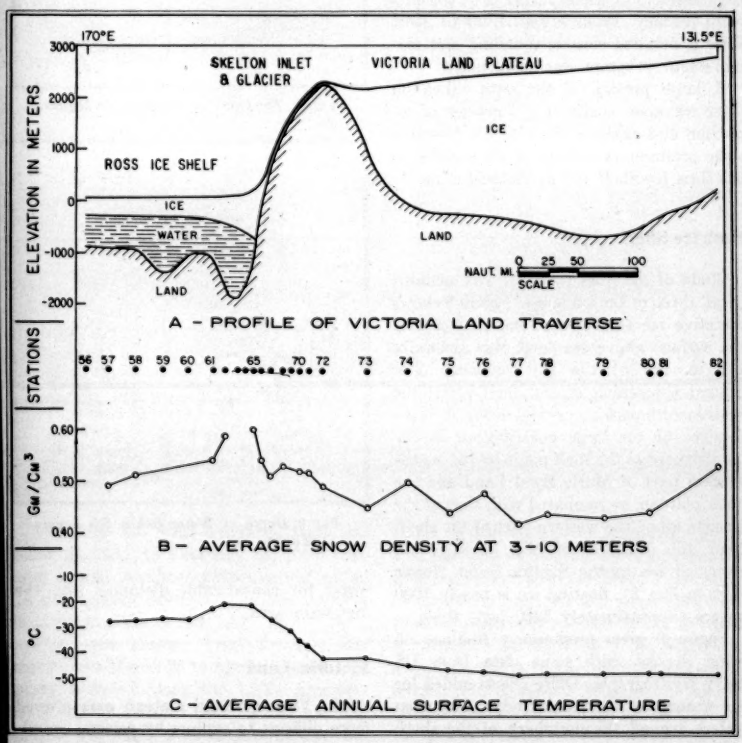

FIG. 10. *Profile from Ross Ice Shelf Westward into Victoria Land Plateau, Showing Surface Elevations, Ice Thickness and Bedrock Topography. Also shown are snow densities and temperatures. The gap in the center segment at Stations 63 and 64 reflects densities greater than 0.8, beyond the scale of the chart. Temperatures were taken at 10-meter depths; experience shows that these approximate average annual air temperatures just above the snow surface.*

require an average climb of 2 meters per nautical mile, or somewhat less than the slope observed at the end of the traverse.

Immediately west of the Skelton Glacier area, surface elevations drop about 150 meters, making it appear likely that drainage of plateau ice through the mountains along the western border of the Ross Ice Shelf is not significant. This is further substantiated by shelf thicknesses shown in Figure 8.

In Figure 10B are plotted the average snow densities between depths of 3 and 10 meters, as found in cores obtained during drilling of seismic shot holes. A significant density increase occurred in the Skelton Glacier area. At Stations 63 and 64, the surface consisted of hard, blue ice with a density greater than 0.8. On the plateau, the densities were generally low but quite erratic, an abnormally high value of .53 being found at the westernmost station.

Figure 10C gives the temperatures at a depth of 10 meters for the profile from the Ross Ice Shelf to the plateau area. (These are quite close to the average annual air temperatures near the snow surface; hence, they represent general climatic conditions.) From an average of —28°C (about —18°F) on the shelf, temperatures fell to —48°C (about —54°F) on the western part of the plateau line. This is not much different from the —50°C at the South Pole Station, more than 700 nautical miles farther south. The rise in temperature in the Skelton Inlet may reflect higher summer temperatures owing to exposed rock areas, or higher winter temperatures resulting from high average down-glacier wind speeds.

During the descent of the Skelton Glacier on the return trip, detailed altimetry was obtained by reading one of the altimeters at short time intervals while the vehicle was in motion. The figures were adjusted to

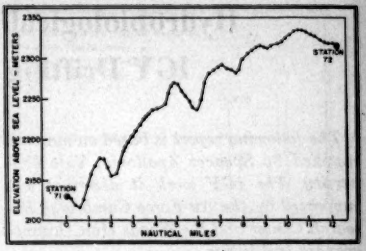

FIG. 11. *Elevations Near Top of Skelton Glacier. The altimetry readings on which these are based were taken during the descent of the glacier on the return trip.*

elevations at the major stations determined from multiple altimetry and transit surveys. Figure 11 shows part of the results of this study near the top of the Skelton Glacier, where the long ridges and troughs were quite pronounced.

An estimate of the average annual snow accumulation on the plateau is not yet available, and preliminary analyses indicate that snow characteristics as obtained from the pit studies may be quite difficult to interpret. If snow accumulation is small and wind erosion high, the changes in oxygen-isotope ratio with season may also be poorly defined. (See *Bulletin No. 21* for a discussion of oxygen-isotope methods.) For reliable information on accumulation patterns, it may be necessary to await future repeat observations of the snow stakes placed on the plateau during this traverse.

Future traverse parties from Scott Base will continue the exploration on the Victoria Land plateau, possibly tying in with French traverse work to the northwest and the USSR work to the west. The combined results will assist in the compilation of a comprehensive picture of this part of the Antarctic continent.

Hydrobiological Measurements on IGY Drifting Station Bravo

The following report is based on material supplied by Spencer Apollonio, Yale University. The IGY work it describes was supported by the Air Force Cambridge Research Center and the Woods Hole Oceanographic Institution.

As part of the IGY program, measurements were made at IGY Drifting Station Bravo, on Fletcher's Ice Island (T-3), to determine the level of primary organic productivity in the Arctic Ocean.

The productivity of the smaller plant and animal life in the sea is important in assessing potential marine food supplies, since fish resources depend on these lower forms of marine life for sustenance. Organic productivity can be determined by measuring the amount of photosynthesis taking place and the concentrations of chlorophyll in the water. The Station Bravo productivity studies included both of these measurements, and also determination of nutrient concentrations.

When the measurements were begun, there was little doubt that productivity would be low because of the unfavorable conditions for life in the Arctic Ocean. Nevertheless, it was hoped that the level could be determined quantitatively, and to some extent this has been achieved, although difficult working conditions made it impossible to accomplish some of the planned measurements.

Complete analysis of the plant and animal collections will take considerable time and the results will be reported later. Advice and assistance were received from J. H. Ryther, C. S. Yentsch, R. A. Vaccaro, and N. W. Corwin. J. A. Murray, Jr. supplied radiation data from Station Bravo observations.

Environmental Conditions

The drift of Station Bravo during this study was along the edge of the continental shelf, within 100 miles of the north coast of the Canadian Arctic Archipelago (see *Bulletin No. 24*). The ice island itself is estimated to be about 160 feet thick. Within a mile of the island the pack-ice thickness, determined from numerous corings, ranged from 10 to 30 feet in an apparently irregular manner. Beyond a mile from the island's edge, the pack ice was extremely broken and no thickness measurements were made.

The hydrobiological sampling site was on the pack ice about 500 feet from the edge of the island. Observations were made through a hole 14 feet in depth.

Hard, windpacked snow covers the ice from late August until about the first week of July. The melt curve for the snow cover of 1957 is shown in Fig. 12. It is probable that during the summer the snow cover is the greatest limiting factor on productivity in the ocean. No light-extinction coefficients are available for the various states of the snow. In April, however, under bright, clear conditions, light penetration was not detectable by a photocell and micro-ammeter at a depth of four inches below the snow surface.

During the summer snow-free period, extensive melt-water lakes cover the pack ice. Preliminary evidence from IGY Drifting Station Alpha (on an ice floe elsewhere in the Arctic Ocean) indicates that these lakes may act as lenses, concentrating light through the ice and increasing organic productivity below them.

Through the summer of 1957, a lead (long, narrow passage in pack ice) about 50 feet wide and 3–4 miles long persisted at a distance of 1½ miles from the sampling

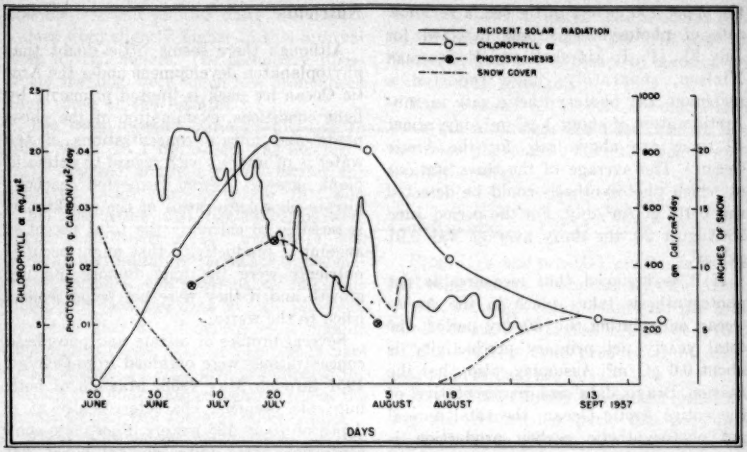

FIG. 12. *Average Thickness of Snow Cover and Average Amounts of Incident Solar Radiation, Photosynthesis, and Chlorophyll a, Summer 1957, at IGY Drifting.*

site. The possible existence of other leads close to the island, or the amount of open water in that part of the ocean, is not known. Visual observations on five aircraft flights to Station Bravo, however, suggest that open water occupies less than 1% of this area in summer. Hence, the effect of ice-free, open water on the results of this study can be considered negligible.

It is significant that patches of diatoms (microscopic algae) frozen in pack ice in the Arctic Ocean, mentioned by Nansen in 1902, and by others, were never noticed in the vicinity of Station Bravo. It is also remarkable that invertebrate animals were never seen, either in the sampling hole or in the lead. Efforts to trap amphipods (small crustaceans) by methods that had proved successful in other parts of the Arctic Ocean were fruitless. One seal was seen in the lead.

Photosynthesis Measurements

During June, July, and August 1957, net photosynthesis (photosynthesis minus respiration) of the phytoplankton—floating plant life—was measured at five locations by the carbon-14 method. (It seems obvious that photosynthetic carbon assimilation is impossible during the winter in higher Arctic latitudes owing to the lack of light during the six-month-long Arctic night.) Water samples were collected by non-metallic samplers. One milliliter of $C^{14}O_3^=$ (activity 2,400,000 counts/min) was added to each sample in a 150-milliliter glass-stoppered bottle and the bottle resuspended for 24 hours at the depth from which the sample was taken. The samples then were filtered through millipore filters; these filters were preserved and the amount of activity later determined at the Woods Hole Oceanographic Institution.

For samples taken at the first two locations, on June 12 and 21, no photosynthesis could be detected by this sensitive technique. Photosynthesis was detected at the other three locations, on July 6, July 12, and August 7.

A maximum rate of 0.024 $gC/m^2/day$ in

the upper 100 meters of the sea, a very low rate of photosynthesis, was detected for July 21. (P. T. Marshall and E. Steeman Nielsen, separately, have reported a maximum net photosynthetic rate in sub-Arctic waters of about 1 gC/m^2/day, about 40 times the above rate for the Arctic Ocean.) The average of the three stations at which photosynthesis could be detected was 0.017 gC/m^2/day. For the period June 20-August 20, the daily average was 0.01 gC/m^2.

If it is assumed that measureable net photosynthesis takes place in the Arctic Ocean only during this 60-day period, the total yearly net primary productivity is about 0.6 gC/m^2. Assuming, also, that the Station Bravo data are representative of the entire Arctic Ocean, the total annual net photosynthetic carbon production is computed at 8.45×10^6 tons. The annual net production for all oceans has been estimated by Steeman Nielsen and E. Aabye Jensen at 1.5×10^{10} tons.

Chlorophyll Concentrations

Water samples were collected and filtered through millipore filters; these filters were preserved and analyzed at Woods Hole for chlorophyll concentrations. The maximum of 0.37 mg/m^3 on August 5, 1957, measured just under the ice, compares closely with the August maximum of 0.4 mg/m^3 found two decades earlier in the upper 20 meters of the Arctic Ocean by the Soviet investigator Shirshov.

It appears from comparisons with similar studies in other Arctic areas that ice-free Arctic waters may develop a maximum chlorophyll concentration as much as 13 times that found in the ice-covered Arctic Ocean. The average concentration in these ice-free waters during one season may vary from 2 to 5 times that of the ice-covered areas. It is significant, however, that even at a depth of 500 meters in the Station Bravo area some chlorophyll could be detected during the summer.

Nutrients

Although there seems little doubt that phytoplankton development under the Arctic Ocean ice pack is limited primarily by light conditions, examination of the phosphate and nitrate concentrations of the water is of interest with regard to potential plant growth. From expected carbon-nitrate-phosphate ratios of the plankton it is possible to calculate the total potential amount of productivity that might occur if nutrients were the only factors limiting growth and if they were not being replenished to the water.

Several profiles of nitrate and phosphate concentrations were obtained from October 1957 through May 1958. Maxima of both nutrients occurred characteristically at a depth of about 125 meters. Phosphate concentrations were quite constant below 200 meters, but nitrate concentrations were more variable below this depth. Minimum values of both nitrates and phosphates were

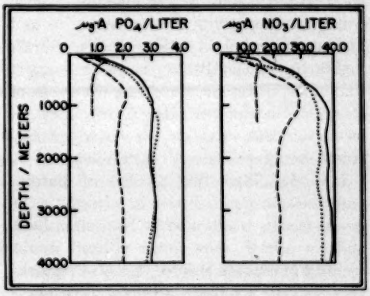

FIG. 13. *Phosphate and Nitrate Concentrations in the Arctic Ocean (dot-dash line) Compared with Concentrations in the Indian Ocean (solid line), Pacific Ocean (dotted line), and Atlantic Ocean (dashed line). Concentrations are shown in microgram atoms (μg-A) per liter.*

found in the upper few meters, and at times nitrates were not detectable at all in the upper levels. Secondary maxima generally existed between depths of 350 and

450 meters, and on two dates the nitrate values were slightly higher in this interval than at 125 meters. The secondary phosphate maxima were much less pronounced than those of the nitrates.

The usual oceanic ratio of nitrogen to phosphorus, 16:1 by atoms, was not regularly observed. In the upper 150 meters, the observed ratios were quite low (5:1 and 9:1), and below 200 meters ratios were higher than expected (17:1 and 27:1). The general distribution of the ratios was somewhat variable. Comparisons of inorganic phosphate data and data on total phosphorus show that at all depths some organic phosphorus exists, dissolved and/or in particles. Figure 13 compares graphically the nitrate and phosphate concentrations of the Arctic Ocean with those of other oceans.

Total phosphorus values from Station Bravo are similar to those reported from the Soviet pre-IGY drifting station, NP-2; data from US-IGY Drifting Station Alpha show the same pattern. (See *Bulletin No. 24* for information about the drift path of Station Alpha and reference to material on its scientific programs.)

Two profiles of nitrate concentrations were taken through the pack ice. No detectable phosphate concentrations were found, however.

Conclusions

From IGY and pre-IGY studies in Arctic and other waters, it appears that the Arctic Ocean, although comprising 1/23 the area of all oceans, contributes only about 1/1000 of the total oceanic production of small plant and animal life.

Even if the paucity of sunlight penetrating the Arctic ice pack did not limit phytoplankton growth, the poverty of the Arctic Ocean in nitrate and phosphate nutrients would still make its productivity level one of the lowest in the world.

IGY Bibliographic Notes

This is the fourteenth of a series of bibliographic notes on IGY programs and findings. The references are selected largely from an IGY bibliography under preparation in the Science and Technology Division of the Library of Congress

IGY Bibliography

The first volume of the International Geophysical Year Bibliography is available from the Publishing and Printing Office, National Academy of Sciences, 2101 Constitution Avenue, N. W., Washington 25, D. C. Price $1.00, postage prepaid. The 64-page volume contains 704 references.

The Bibliography is being compiled at the Library of Congress and is a joint project of the Library, the Academy, and the National Science Foundation.

S. K. Chakrabarty: Cosmic Ray Work at the Bengal Engineering College, Howrah. *Journal of Scientific and Industrial Research*, Vol. 17A, no. 12. Dec. 1958. Pp. 81–82. Diagr.

M. W. Chiplonkar, R. N. Karekar, T. A. Raju, and M. S. Hattiangadi: A Preliminary Report "On the Nature and Origin of Atmospherics." *Journal of Scientific and Industrial Research*. New Delhi, India. Vol. 17A, no. 12, Dec. 1958. Pp. 3–23. Diagr., refs.

Herbert Friedman: Rocket Observations of the Ionosphere. *Proceedings of the IRE*. Vol. 47, no. 2. Feb. 1959. Pp. 272–280. Diagr.

Roger M. Gallet: The Very-Low-Frequency Emissions Generated in the Earth's Exosphere. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 211–231. Illus., diagr.

E. I. Gal'perin, A. V. Goriachev, and S. M. Zerev: Crustal Structure Researches in the Transition Region from the Asiatic Continent to the Pacific. (In Russian). *Izd-vo Akademii Nauk SSR*. 28 pp. Diagr., maps.

I. Harris and R. Jastrow: *Demise of Satellites 1957 Alpha and 1957 Beta*. Washington, Naval Research Laboratory. 1958. Miscellaneous Paper No. 165.

R. A. Helliwell and M. G. Morgan: Atmospheric Whistlers. *Proceedings of the IRE*. Vol. 47, no. 2. Feb. 1959. Pp. 200–208. Illus., diagr., map.

The International Geophysical Year and Space Research. U. S. Congress. House of Representatives. *Staff Report of the Select Committee on Astronautics and Space Research*. Washington, Government Printing Office. 1959. 36 pp.

J. B. Kalinin: Soviet Investigation of Geomagnetism. (In Russian). *Priroda*. No. 8. Aug. 1958. Pp. 50–55. Diagr., maps.

D. C. King-Hele: Density of the Atmosphere at Heights between 22 KM. and 400 KM. from Analysis of Artificial Satellite Orbits. *Nature*. Vol. 183, no. 4670. May 2, 1959. Pp. 1224–1227. Diagr.

K. M. Kotadia: Meteors and E_s Ionization. *Journal of Scientific and Industrial Research*. Vol. 17A, No. 12. Dec. 1958. Pp. 46–49. Diagr.

M. G. Krishnamurthi, G. Sivarama Sastry, and T. Seshagiri Rao.: Radio Emission from the Sun at 30 MC/S. *Journal of Scientific and Industrial Research*, Vol. 17A, no. 12. Dec. 1958. Pp. 71–73. Refs.

La Fusée Lunaire Expérimentale à Satellite: Pioneer I. *Fusée et Recherche Aeronautique*. Vol. 3, No. 3. 1958. Pp. 119–122. Illus., diagr.

E. M. Lin'kov: Study of the Elastic Properties of Ice Cover in the Arctic. (In Russian). *Vestnik Leningradskogo Universiteta*. No. 4. *Seriia Fiziki i Khmii*. No. 1. 1958. Pp. 17–22. Diagr.

Ludwik Liszka: A Type of Variation of the Signal Strength from 1958 δ 2 (Sputnik 3). *Nature*. Vol. 183, no. 4672. May 16, 1959. Pp. 1383–1384. Diagr.

George H. Ludwig: Cosmic-Ray Instrumentation in the First U. S. Earth Satellite. *Review of Scientific Instruments*. Vol. 30. April 1959. Pp. 223–229. Illus., diagr.

S. L. Malurkar: Geomagnetic Work at Albag, Annamalainagar and Trivandrum during the IGY. *Journal of Scientific and Industrial Research*. Vol. 17A, no. 12. Dec. 1958. Pp. 33–35. Refs.

D. F. Martyn: The Normal F Region of the Ionosphere. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 147–155. Diagr.

W. G. Metcalf: Oceanographic Data from Crawford Cruise 16, Oct. 1–Dec. 11, for the International Geophysical Year. *Woods Hole Oceanographic Institution*. June 1958. 127 pp. Diagr., map. Reference No. 38–31.

G. R. Miczaika and E. W. Wahl: *The Orbital Motion of the Earth Satellite 1957 β from April 1 to its Decay April 14, 1958*. Bedford, Mass., Air Force Cambridge Research Center. June 5, 1958. 38 pp. Diagr., maps.

A. P. Mitra, K. A. Sarada, N. V. G. Sarma, and M. N. Joshi: Radio Patrol of Solar Flares. *Journal of Scientific and Industrial Research*. Vol. 17A, no. 12. Dec. 1958. Pp. 74–80. Illus., diagr.

B. Mongin: Les Terres Australes et Antarctiques Françaises. *Forces Aériennes Françaises*. Vol. 13, no. 144. Jan. 1959. Pp. 83–104. Illus., maps.

Benjamin Nichols: Auroral Ionization and Magnetic Disturbances. *Proceedings of the IRE*. Vol. 47. Feb. 1959. Pp. 245–254. Diagr.

M. M. Nita: On the Motion of Artificial Satellites Taking into Account the Resistance of the Medium. *Revue de Mécanique Appliquée*. Vol. 3, no. 1. 1958. Pp. 57–76. Diagr.

Programme of IGY Solar Observations in India. *Journal of Scientific and Industrial Research*. Vol. 17A, no. 12. Dec. 1958. Pp. 68–69. Refs.

B. Ramachamara Rao and D. Satyanarayana Murty: A New Continuous Wave Radio Method for the Study of Ionospheric Drifts. *Journal of Scientific and Industrial Research*. Vol. 17A, no. 12. Dec. 1958. Pp. 63–67. Diagr., refs.

Report of the Bureau of the Advisory Council for the IGY (Otchet biuro SK MGG). *Informatsionnyi Biulleten' Mezhdunarodnogo Geofizicheski. Goda*. No. 4. 1958. Pp. 3–7.

R. Sethuraman: Rates of Fading of Reflected Pulses of Vertically Incident Electromagnetic Waves at Ahmedabad on 2.6 and 4.0 MC/S. *Journal of Scientific and Industrial Research*. Vol. 17A, no. 12. Dec. 1958. Pp. 50–53. Diagr., refs.